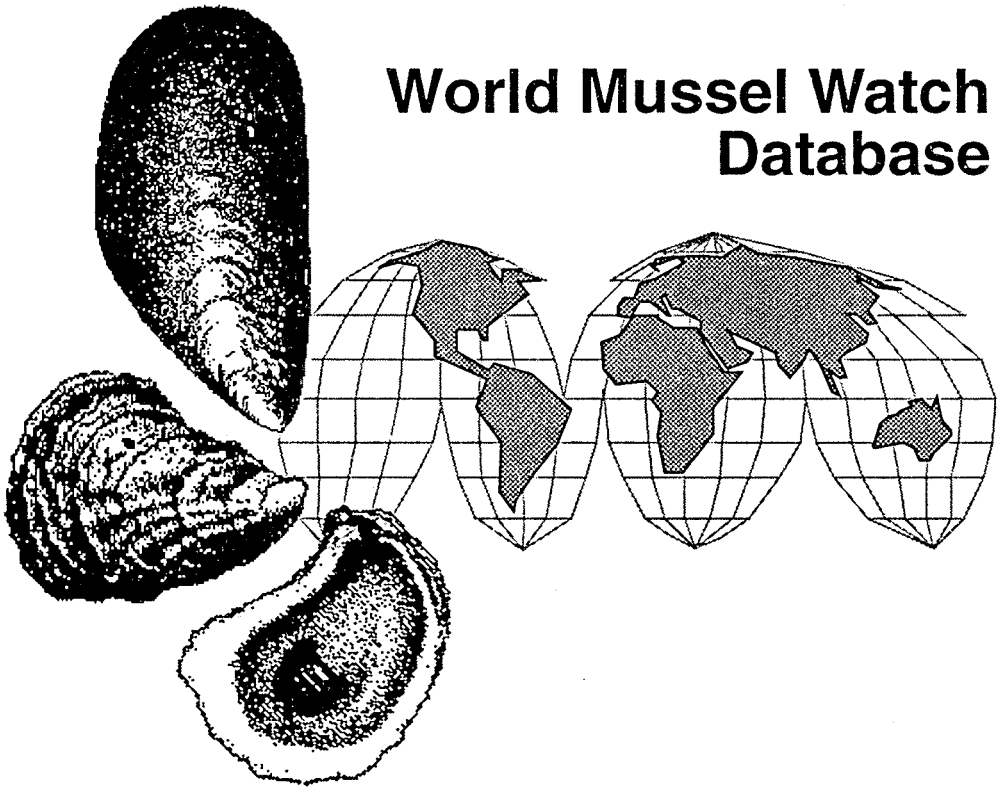
NOAA Technical Memorandum NOS ORCA 109

National Status and Trends Program
for Marine Environmental Quality



World Mussel Watch Database

Silver Spring, Maryland
April 1997

US Department of Commerce

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service

Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
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Notice

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A. Y. Cantillo

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April, 1997

United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
William M. Daley Secretary	D. James Baker Under Secretary	W. Stanley Wilson Assistant Administrator

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AAS	Atomic absorption spectrometry
APDC	Ammonium pyrrilidine dithiocarbamate
ASV	Anodic stripping voltammetry
BCR	Community Bureau of Reference
CRM	Certified reference material
FAO	Food and Agriculture Organization, United Nations
GFAAS	Graphite furnace atomic absorption spectrometry
GIPME	Global Investigation of Pollution in the Marine Environment
GLOSS	Global Sea Level Observing System
GOOS	Global Ocean Observing System
IAEA	International Atomic Energy Agency
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
IGOSS	Integrated Global Ocean Services System
INAA	Instrumental neutron activation analysis
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data Exchange
JGOFS	Joint Global Ocean Flux Study
MARPOLMON	Marine Pollution Monitoring System
MIBK	Methyl isobutyl ketone
NIES	National Institute for Environmental Studies, Japan
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council, Canada
NS&T	National Status and Trends Program
QA	Quality assurance
RNO	Réseau National d'Observation de la Qualité du Milieu Marin
SRM	Standard reference material produced by NIST
TOGA	Tropical Ocean Global Atmosphere
UNEP	United Nations Environment Programme
WMO	World Meteorological Organization
WMW	World Mussel Watch database
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch
XRF	X-ray fluorescence spectrometry

World Mussel Watch Data

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ABSTRACT

The Global Ocean Observing System (GOOS) is an internationally coordinated system for systematic operational data collection and analysis. The NOAA NS&T Program assesses the current status of, and changes over time, in the environmental health of the estuarine and coastal waters of the United States. NS&T is, therefore, part of GOOS. This contribution to GOOS is an attempt to determine the levels of contaminants in mussels and oysters collected worldwide and to compare the results with the long-term Mussel Watch programs of the United States and France. A comprehensive literature search of studies using any species of mussels and/or oysters worldwide to monitor the levels of trace metals and organic contaminants was conducted and the data compiled into the World Mussel Watch database. Data sources and statistics of the database are included. Results of the World Mussel Watch and the US and France Mussel Watch programs were compared and typical levels of some trace metals in uncontaminated mussels and oysters were calculated.

1. INTRODUCTION

Mussel Watch programs have been used since the 1970s to assess coastal environmental pollution. Currently, there is an increased awareness of possible global environmental changes perhaps caused, in part, by man's activities. As part of the Global Ocean Observing System (GOOS), the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) Program undertook the task of compiling results worldwide of Mussel Watch programs as far back in time as possible, in an effort to determine whether there have been changes in the global level of some trace metals detected in mussels and/or oysters. This report is a description of that effort.

2. GLOBAL OCEAN OBSERVING SYSTEM

GOOS is an internationally coordinated system for systematic operational data collection (measurements), data analysis, exchange of data and data products, technology development and transfer (Intergovernmental Oceanographic Commission, 1993). GOOS uses a globally coordinated, scientifically based strategy to allow for monitoring and subsequent prediction of environmental changes globally, regionally and nationally. The objective of the GOOS is to ensure global, permanent, systematic observations adequate for forecasting climate variability and change; for assessing the health or state of the marine environment and its resources, including the coastal zone; and for supporting an improved decision-making and management process, which takes into account potential natural and man-made changes in the environment and their effects on human health and resources. GOOS will provide a mechanism and infrastructure for data and information to be made available on various time scales to participating nations.

The GOOS was established by Member States and implemented through nationally owned and operated facilities and services. Coordination is provided by the Intergovernmental Oceanographic Commission (IOC) in cooperation with the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP) and the International Council of Scientific Unions (ICSU). The GOOS is based on the principle that all countries should participate and that participants should make certain commitments, according to their capabilities to fulfill such commitments, so that all countries can benefit. GOOS will be developed from operational and scientific data gathering systems and activities already in place, such as Integrated Global Ocean Services System (IGOSS), Marine Pollution Monitoring System (MARPOLMON), Global Sea Level Observing System (GLOSS), Joint Global Ocean Flux Study (JGOFS), World Ocean Circulation Experiment (WOCE), Tropical Ocean Global Atmosphere (TOGA) and others. Observations should be: long term, systematic, relevant to the global system, cost effective and routine.

Sponsors have agreed that GOOS will comprise the following five "application modules," whose objectives may overlap and share some of the same data but which have distinct purposes:

- Climate, Monitoring, Assessment and Prediction, including seasonal and interannual variability
- Monitoring and Assessment of Living Marine Resources
- Monitoring of the Coastal Zone Environment and its Changes
- Assessment and Prediction of the Health of the Ocean
- Marine Meteorological and Oceanographic Services

3. NOAA NATIONAL STATUS AND TRENDS PROGRAM AND IFREMER RNO MUSSEL WATCH PROGRAM

The NOAA NS&T Program assesses the current status of, and changes over time, in the environmental health of the estuarine and coastal waters of the United States, including Alaska and Hawaii. The Mussel Watch Project is one of the major producers of NS&T data concerning environmental concentrations of contaminants. Concentrations of organic and inorganic contaminants in sediments and bivalves taken in the same area are determined as part of the Mussel Watch Project at sites located around the nation. The bivalves are collected on a biennial basis from approximately 240 sites in the United States, while sediments are collected at the same sites on a less frequent basis. The analytes include 24 polycyclic aromatic hydrocarbons, 20 polychlorinated biphenyl congeners, DDT and its metabolites, nine other chlorinated pesticides, organotins, four major elements, and twelve trace elements. NS&T Program sampling and analyses methods are described in Lauenstein and Cantillo (1993). NS&T sampling sites are described in Lauenstein, Harmon, and Gottholm (1993). The quality of the NS&T analytical data is overseen by the Quality Assurance (QA) Project, designed to assure and document the quality of the data, to document sampling protocols and analytical procedures, and to reduce intralaboratory and interlaboratory variation (Cantillo and Lauenstein, 1993). O'Connor and Beliaeff (1995) and O'Connor (1996) have summarized NS&T Mussel Watch data through 1993. The data are available upon request or via the Internet at: <http://www.orca.nos.noaa.gov/projects/nsandt/nsandt.html>. Results of the analysis of zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected in the Great Lakes by the NS&T Program were not included in the comparison.

Since 1979, the Réseau National d'Observation de la Qualité du Milieu Marin (RNO) has been collecting and analyzing mussels and oysters along the French coast (Beliaeff *et al.,* 1997). The RNO Mussel Watch is funded by the French Ministry of the Environment and managed by the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER). The RNO program collects samples at approximately three month intervals. The specimens collected are *Mytilus edulis*, *Mytilus galloprovincialis*, *Ostrea edulis,* and *Crassostrea gigas*. The specimens are analyzed for trace metals and organic pollutants. The RNO data can be obtained by contacting D. Claisse, IFREMER, BP 1105, 44311 Nantes Cedex 03, France.

4. WORLD MUSSEL WATCH DATA

NS&T, by its nature, is a part of GOOS. To meet the global aspect of GOOS, the NS&T Program established a World Mussel Watch (WMW) database that is comprised of data generated by chemical measurements of levels of contaminants in species of oysters and mussels worldwide. The database includes small, localized studies as well as some multiyear monitoring programs. As points of reference, the WMW data were compared to those from two very large Mussel Watch programs: the NS&T and RNO programs.

A comprehensive literature search of studies using any species of marine or estuarine mussels and/or oysters worldwide to monitor the levels of trace metals and organic contaminants was conducted and whenever possible copies of the citations were obtained. The data sets of the NOAA NS&T and RNO Mussel Watch efforts were not added to the WMW database. The results of these programs were treated separately since the number of data points of these two programs is larger than that of the WMW data.

The trace organic contaminant data found in the citations were difficult to compare from one source to another. There have been changes in analytical methodology for the analysis of trace organic contaminants in the environment over the last two decades so comparison of older data with more recent data even from the same source may not be valid. Often, insufficient analytical methodology detail was available in citations in order to judge to what degree one set of data could be compared to another. It was decided, therefore, not to include the trace organic contaminant levels in the WMW at this time.

Numerical results of the analysis of Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Sn, Sb Hg, Tl, and Pb in mussels and oysters were entered into four files to created the WMW database: TM DRY, TM WET, TM RANGES DRY and TM RANGES WET. The TM DRY file contains data reported on a dry weight basis. Data from citations which contained both dry and wet weight concentrations were entered only in the TM DRY file. If there was sufficient information in the citation to convert wet weight results to dry weight, the concentrations were converted and added to the TM DRY file. The TM WET file contains concentrations on a wet weight basis. TM RANGES DRY contains mean, low and high concentrations reported on a dry weight basis, and TM RANGES WET contains mean, low and high concentrations reported on a wet weight basis.

4.1. Data fields for TM DRY and TM WET files

SOURCE: Internal assigned code that relates the data to the source, usually an article in a journal, a data report or a database. Codes are internal identification numbers. Those with dashes such as "19-H-1" were assigned by Kidder (1977).

LATITUDE: Latitude of sampling site, often estimated from maps to ±0.1°. Western latitudes are listed as negative values (i.e., 27° 30' W was entered as -27.5.). If location was not specified, then an

	approximation was made, i.e., for East Coast of the US, the Mid-Atlantic coast was chosen.
LONGITUDE:	Longitude of sampling site, often estimated from maps to ±0.1°. Southern longitudes are listed as negative (i.e., 40° 30' S was entered as -40.5.). If location was not specified, then an approximation was made, i.e., for East Coast of the US, the Mid-Atlantic coast was chosen.
SPECIES:	Code for species included in the database. Codes are listed in Table 1.
SPP:	Notation of whether data are for oyster (O) or mussels (M).
LOCATION:	Sampling site within a larger area.
BAY:	Geographical area in which sampling site is located.
COUNTRY:	Country where sampling took place.
YEAR:	Sampling date in year and decimal month (e.g., June 1970 was listed as 1970.5). The fractions used are listed in Table 2. If no sampling date was listed in the data source, the publication year was used. If a period of time was listed, then the time half way between the two stated sampling dates was used.
SIZE:	Size range (mm) of specimens sampled.
NUMBER PER COMPOSITES:	Number of specimens used to prepare a composite sample.
NUMBER OF COMPOSITES:	Number of composite samples analyzed per site.
CONCENTRATIONS:	Total content of analyte (Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Sn, Sb Hg, Tl or Pb) in tissue samples on a dry weight basis. If information was available, any data listed as wet weight were converted to dry weight. If this was not possible, the wet weight information was listed in a separate file of the database. Values listed as not detected were entered in the database as zeroes. Values listed as below a specific detection limit were listed at that level (e.g., <5.0 was listed as 5.0). No notation was made to differentiate between an actual concentration or a detection limit entry. Only initial conditions data of transplant studies were used. Many citations displayed the data graphically. If the numerical values were shown in the graphical display, then these were added to the database. No attempt was made to obtain approximate concentrations from graphical data displays although this may be possible in many cases.

Table 1. Species of mussels and oysters represented in the WMW database.

Code	Scientific name	Common name
O	Unspecified oyster species	
M	Unspecified mussel species	
AZ	*Arca zebra* (Swainson 1833)[1]	Atlantic turkey wing
AN	*Atrina novazealandia*	Horse mussel
AA	*Aulacomya ater* (Molina 1782)[1]	Black ribbed mussel
AM	*Aulacomya maoriana* (Iredale 1915)[2] *	Maori mussel
BE	*Brachidontes exustus* (Linné 1758)	Mussel
BV	*Brachidontes variabilis*	Mussel
CCH	*Choromytilus chorus* (Molina 1782)	Mussel (Chile)
CM	*Choromytilus meridionalis* (Krauss 1848)[3] Δ	Mussel
CA	*Crassostrea angulata* (Lamarck 1819)[4]	Portuguese oyster
CCM	*Crassostrea commercialis* ◊	Rock oyster
CC	*Crassostrea corteziensis* (Hertlein 1951)[5] ◆	Oyster
CCU	*Crassostrea cucullata* ◊	Oyster
CG	*Crassostrea gigas* (Thunberg 1793)[1]	Giant Pacific oyster
CGL	*Crassostrea glomerata* (Gould 1850)[1]	Auckland rock oyster
CI	*Crassostrea iridescens* (Hanley)	Oyster
CMA	*Crassostrea margaritacea* (Lamarck 1819)[3]	Cape rock oyster
CR	*Crassostrea rhizophorae* (Guilding 1828)[1] ✪	Caribbean edible oyster
CV	*Crassostrea virginica* (Gmelin 1791)[1]	Eastern American oyster
DP	*Dreissena polymorpha*	Zebra mussel
GA	*Gryphaea angulata*	Portuguese oyster
IA	*Isognomon alatus* (Gmelin 1791)[1]	Flat tree oyster
IB	*Isognomon isognomon* (Linné 1758)[6]	Tree oyster
MA	*Modiolus auriculatus* (Krauss 1848)[3]	Mussel
MCA	*Modiolus capax* (Conrad 1837)[5]	Fat horse mussel
MD	*Modiolus demissus* ✻	Mussel
MM	*Modiolus modiolus* (Linné 1758)[1]	Northern horse mussel
MC	*Mytilus californianus* (Conrad 1837)[1]	California mussel
MCS	*Mytilus coruscus* (Goud 1861)[7]	Hard shell mussel
ME	*Mytilus edulis* (Linné 1758)[1]	Blue mussel
MEA	*Mytilus edulis aoteanus* (Powell 1958)[2]	Mussel
MEC	*Mytilus edulis chilensis*	Mussel
MEP	*Mytilus edulis planulatus* (Lamarck 1819?)[2]	Mussel
MF	*Mytella falcata* (d'Orbigny 1846)[1]	Falcate swamp mussel
MG	*Mytilus galloprovincialis* (Lamarck 1819)[1]	Mediterranean blue mussel
MMA	*Mytilus magellanicus*	Mussel
MMI	*Mytilus minimus*	Mussel
MO	*Mytilus obscurus*	Mussel
MP	*Mytilus platensis* (Orbigny 1846)[8] ▼	Mussel
MS	*Mytilus smaradignus* ✖	Mussel
MV	*Mytilus viridis* (Linné 1758)[1]	Green mussel
OA	*Ostrea angasi* (Sowerby 1871)[6] ✣	Oyster
OAG	*Ostrea angulata*	Oyster
OC	*Ostrea circumpicta*	Oyster

Table 1. Species of mussels and oyters represented in the WMW database (cont.).

Code	Scientific name	Common name
OE	*Ostrea edulis* (Linné 1758)[1]	Common European oyster
OG	*Ostrea gigas* ●	Oyster
OL	*Ostrea lurida* (Carpenter 1864)[1]	Native Pacific oyster
OLU	*Ostrea lutaria* (Hutton 1873)[2]	Bluff oyster
OP	*Ostrea pliculata*	Oyster
OS	*Ostrea sinuata* (Lamarck 1819)[9]	Pt. Lincoln oyster
OSP	*Ostrea spinosa*	Oyster
PC	*Perna canaliculus* (Gmelin 1791)[1]	Channel mussel
PP	*Perna perna* (Linné 1758)[1]	Brown mussel
PV	*Perna viridis* (Linné 1758)	Green-lipped mussel
PCA	*Pinctada carchariarium* (Jamieson 1901)[9]	Shark Bay pearl oyster
PM	*Pinctada margaritifera* (Linné 1758)	Black-lipped pearl oyster
PEP	*Perumytilus purpuratus*	Mussel (Chile)
PR	*Pinctada radiata*	Kuwait pearl oyster
SC	*Saccostrea commercialis*	Sydney rock oyster
SCC	*Saccostrea cucullata* ◊	Oyster
SE	*Saccostrea echinata* (Quoy and Gaimard 1835)[10]	Spiny oyster
SG	*Saccostrea gigas*	
SI	*Saccostrea iridescens* (Gray in Hanley 1854)[5]	Iridescent oyster
SS	*Semelle solida*	Mussel (Chile)
SH	*Stavelia horrida* (Dunker 1856)[6]	Hairy mussel
TD	*Tagellus dombeii*	Mussel (Chile)
TL	*Tiostria lutaria* ☆	Oyster

* *A. ater maoriana* (Iredale 1915) listed in Powell (1979) may be the same as *A. maoriana*.
Δ Form of *A. ater* (Kilburn and Rippey, 1982).
◊ *C. commercialis*, *C. cucullata*, and *Saccostrea cucullata* are the same species.
◆ Probably the same as *Ostrea corteziensis*.
✪ *C. brasiliana* and *C. rhizophorae* are probably the same species.
✻ *M. demissus*, *M. demissus plicatus*, *M. demissus plicatulus* and *Geukensia demissa* are the same species (Abbott, 1974).
▼ Probably same as *M. edulis platensis*.
✖ Probably same as *M. viridis* (Abbott and Dance, 1982).
✣ Same as *O. sinuata* (Cotton and Godfrey, 1938).
● Probably same as *C. gigas* (Powell, 1979).
☆ Same as *O. lutaria*.

1, Abbott and Dance (1982); 2, Powell (1979); 3, Kilburn and Rippey (1982); 4, Tebble (1976); 5, Olsson (1961); 6, Wells and Bryce (1986); 7, Kira (1965); 8, Rios (1985); 9, Cotton and Godfrey (1938); 10, and 10, Habe and Ito (1970).

Table 2. Month conversion to fraction years.

Month	Fraction of year	Month	Fraction of year	Month	Fraction of year
January	0.08	May	0.42	September	0.75
February	0.17	June	0.50	October	0.83
March	0.25	July	0.58	November	0.92
April	0.33	August	0.67	December	0.99

4.2. Data fields for TM RANGES DRY and TM RANGES WET files

Data were put into these fields if they were reported as means and ranges. If the only data reported were means and ranges, then only that data appear in the WMW database. If individual sample data were also reported then those appear in the TM DRY or TM WET files. In addition to the field listed above, the LOW, HIGH and MEAN values were listed in the TM RANGES DRY and TM RANGES WET files.

4.3. Source descriptions

There have been many studies reporting the results of analyses of mussels or oysters for a variety of analytes. These citations include many contamination level studies, although some of the oldest available data were reported as part of food content studies. Data were sometimes listed in the citation, although often only a graphical presentation was available. Some attempts were made to contact the authors of such publications in order to obtain tabular listings of the data but this was unsuccessful. The sources of data entered into the WMW database are listed in chronological order of sampling year(s) in Appendix I, and within each year, alphabetically by country where the sampling took place and author. The information listed for each source includes:

YEAR: Year of sampling if known. Otherwise, the publication year of the citation was used.

COUNTRY: Country or countries where sampling took place.

SOURCE: Internal randomly assigned code that relates the data to the source, usually an article in a journal, a data report or a database. Codes are internal identification numbers. Those with dashes such as "19-H-1" were assigned by Kidder (1977).

SPECIES: Full species name(s).

NUMBER OF SITES: The number of sites sampled

ANALYTICAL METHODOLOGY: An indication of whether the analytical methodology used was described in the paper, in a cited paper or was not available.

QUALITY ASSURANCE: An indication of whether a quality assurance protocol was included in the paper.

ANALYTES: The analytes determined. If analytes other than the ones included in the WMW database were available in the paper, these are listed in parenthesis.

CITATION: The full bibliographic information of the paper where the data were found.

ABSTRACT: An abstract listing the purpose of the study, including: when available, short descriptions of the sampling and analytical methods, and the use of reference materials.

Country, analyte and author indices to Appendix I are found in Appendix II. The bibliography of the sources used is in Appendix III.

4.4. Database availability

The WMW database is available from the author and resides at the offices of the Coastal Monitoring and Bioeffects Assessment Division, Office of Ocean Resources Conservation and Assessment, NOAA National Ocean Service.

4.5. Database statistics

4.5.1. Geographical distribution of the data

The distribution of data by latitude and longitude is shown in Figure 1. The countries for which mussel and/or oyster data were found are listed in Table 3. The scarcity of data from South America, Africa and other areas is apparent. Currently, efforts are underway to collect and analyze mussel or oyster samples from these areas.

4.5.2. Time distribution

The histogram of years for which data are included in the WMW database is shown in Figure 2. Some data are available from the turn of the century and early in the 20th century. These were mostly studies of the use of oysters in the treatment of anemia. No data were found for the decade of the 1940s, probably due to the Second World War. The large increase in data in the 1970s reflects the beginning of the environmental movement and the inception of "Mussel Watch" monitoring by Goldberg *et al.* (1978).

4.5.3. Distribution of analyte concentrations

The number of data points, and the low, high and mean concentrations for each element in each of the four data files for mussels and oysters in the WMW database are listed in Tables 4 and 5. The data for each element in each file were combined and the results described statistically and graphically in Appendix IV in order of atomic number.

Oysters and mussels are not equal in their ability to concentrate trace elements (O'Connor, 1993). The trace elements Ag, Cu, and Zn are enriched in the oyster *C. virginica* relative to the mussel *M. edulis*. Conversely, Cr and Pb are more than three times higher in the mussel than in the oyster. Therefore, in the WMW data sets, mussels and oysters were treated separately.

The Cr, Ni, Cu, Zn, Cd and Pb data for mussels and oysters were found to be log normal in distribution. The As data also appear to be log normal although the distribution may be bi-modal.

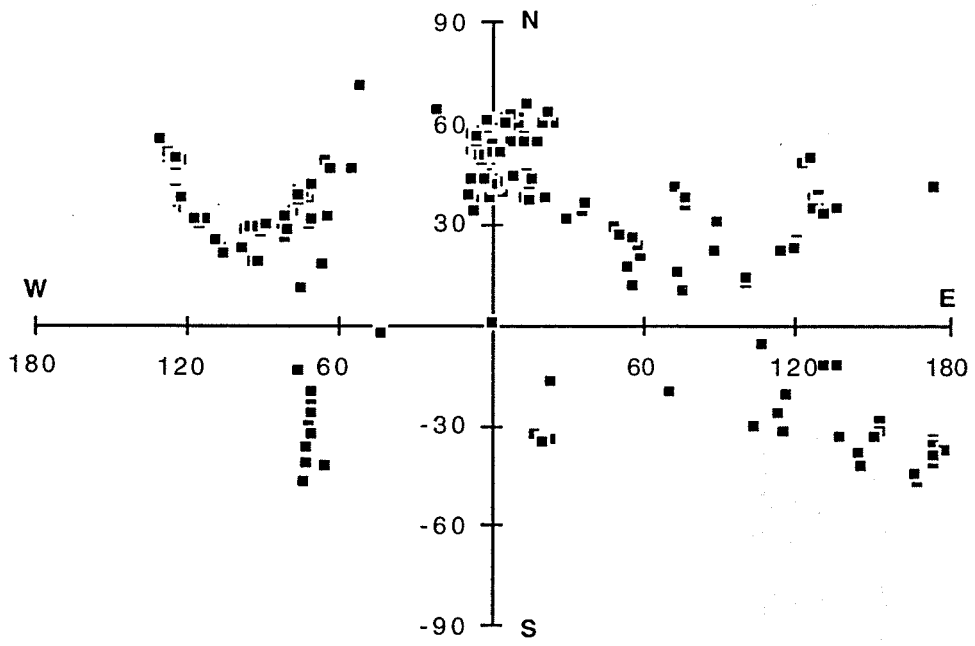

Figure 1. Geographical distribution of all sampling locations in WMW database.

Table 3. Countries or territories represented in the WMW database.

Argentina	Hong Kong	Peru
Australia	Iceland	Poland
Bahrain	India	Portugal
Belgium	Indonesia	Puerto Rico
Bermuda	Ireland	Russia
Brazil	Isle of Man	Scotland
Canada	Italy	Singapore
Chile	Japan	South Africa
Colombia	Korea	Spain
Croatia	Kuwait	Sweden
Denmark	Lebanon	Taiwan
Egypt	Mexico	Thailand
England	Monaco	The Netherlands
Finland	Morocco	United States
France	New Zealand	Wales
Germany	Northern Ireland	Yugoslavia
Greece	Norway	
Greenland	Oman	

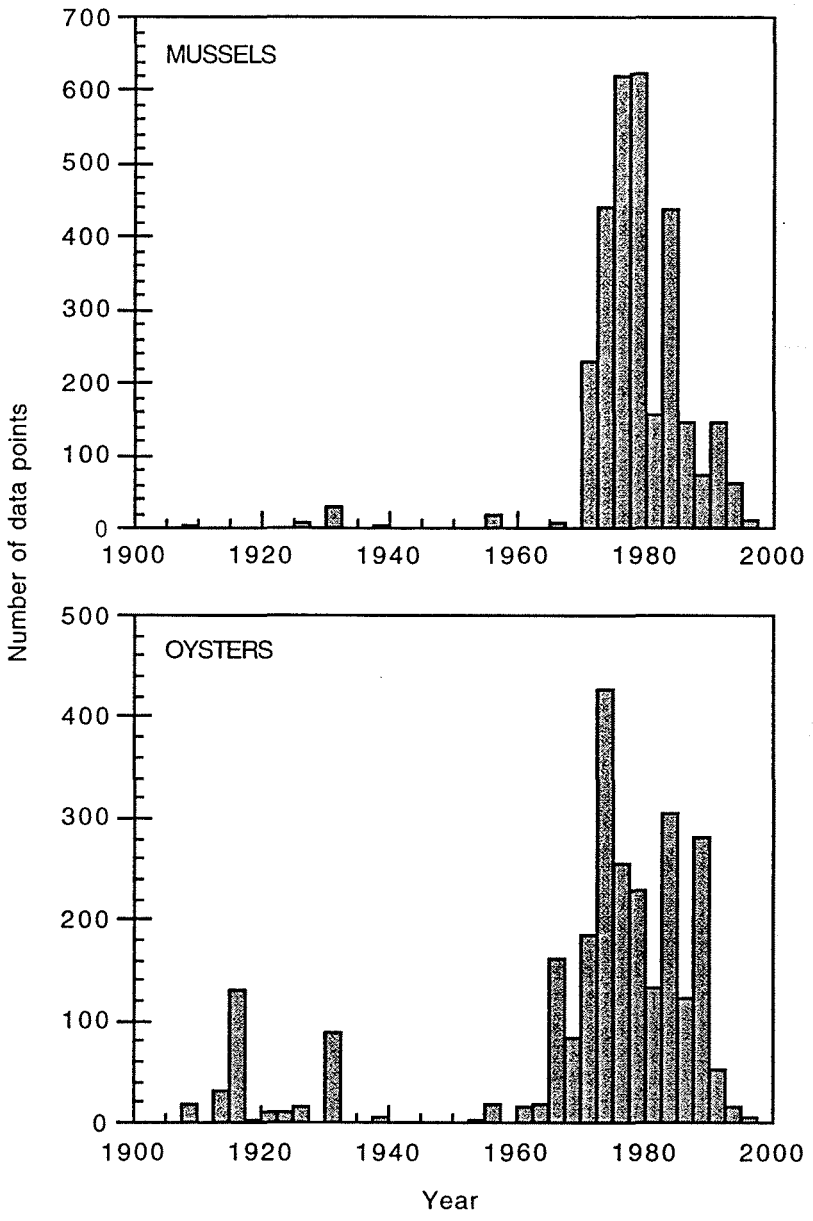

Figure 2. Histogram of years for which data is available for mussels and oysters in the WMW database.

Table 4. Statistics per element for mussel data in the WMW database.

	Number of entries	Concentration (µg/g dry wt.) and source: Lowest*	Highest	Overall mean
Mussels				
Dry weight (TM DRY):				
Cr	486	0.10	320	5.0
Ni	718	0.26	2350	7.3
Cu	1355	1	4304	44
Zn	1486	4	14045	290
As	174	0.2	370	17
Se	88	0.01	27	3.1
Ag	431	0.02	82	1.2
Cd	1444	0.02	366	5.7
Sn	16	0.52	9	3.6
Sb	18	0.042	5.5	2.0
Hg	671	0.001	1906	9.0
Tl	3	1.6	2.1	1.9
Pb	1358	0.15	3100	18
Dry weight (TM RANGES DRY):				
Cr	33	0.1	7.1	1.5
Ni	44	0.78	31	2.8
Cu	66	0.46	158	11
Zn	94	3.4	460	110
As	5	4.1	16.9	10
Se	0	-	-	-
Ag	6	0.072	0.3	0.15
Cd	75	0.13	21	2.0
Sn	5	1.3	5	3.4
Sb	0	-	-	-
Hg	29	0.07	2.3	0.79
Tl	0	-	-	-
Pb	60	0.54	50	10

Table 4. Statistics per element for mussel data in the WMW database (cont.).

	Number of entries	Concentration (µg/g dry wt.) and source: Lowest*	Highest	Overall mean
Mussels				
Wet weight (TM WET):				
Cr	203	0.02	22	1.3
Ni	15	0.1	1.0	0.54
Cu	450	0.08	162	4.8
Zn	463	0.46	700	37
As	10	0.085	119	46
Se	0	-	-	-
Ag	7	0.02	0.14	0.07
Cd	447	0.03	21	0.95
Sn	0	-	-	-
Sb	3	0.2	13	6.3
Hg	217	0.008	32	1.0
Tl	0	-	-	-
Pb	418	0.01	1300	13
Wet weight (TM RANGES WET):				
Cr	6	0.018	0.086	0.03
Ni	5	0.17	0.32	0.25
Cu	18	0.35	7.5	2.5
Zn	18	4.3	59	20
As	0	-	-	-
Se	0	-	-	-
Ag	0	-	-	-
Cd	27	0.03	2.6	0.58
Sn	0	-	-	-
Sb	0	-	-	-
Hg	31	0.008	50	1.8
Tl	0	-	-	-
Pb	21	0.47	3	1.2

* Lowest reported concentration or detection limit.

Table 5. Statistics per element for oyster data in the WMW database.

	Number of entries	Concentration (µg/g dry wt.) and source: Lowest*	Highest	Overall mean
Oysters				
Dry weight (TM DRY):				
Cr	217	0.03	42	3.5
Ni	188	0.01	13	2.4
Cu	919	3	6527	358
Zn	798	17	99220	4140
As	185	0.2	920	16
Se	0	-	-	-
Ag	202	0.1	36	2.8
Cd	709	0.001	204	11
Sn	96	0.11	14	2.2
Sb	3	0.010	0.015	0.012
Hg	169	0.02	2.4	0.39
Tl	0	-	-	-
Pb	538	0.02	400	6.0
Dry weight (TM RANGES DRY):				
Cr	9	0.49	6	1.4
Ni	4	2.8	78	25
Cu	99	1.4	2161	201
Zn	88	206	7167	1600
As	13	0.095	65	11
Se	7	0.41	5.6	3.2
Ag	0	-	-	-
Cd	20	0.76	6.7	2.1
Sn	2	9	10	9.5
Sb	0	-	-	-
Hg	20	0.003	0.21	0.076
Tl	0	-	-	-
Pb	6	1.04	7.6	4.4

Table 5. Statistics per element for oyster data in the WMW database (cont.).

	Number of entries	Concentration (µg/g dry wt.) and source: Lowest*	Highest	Overall mean
Oysters				
Wet weight (TM WET):				
Cr	108	0.2	20	0.99
Ni	114	0.01	12	0.93
Cu	922	0.07	2722	62
Zn	815	1.2	7670	410
As	75	0.1	70	3.7
Se	0	-	-	-
Ag	46	0.85	1.9	4.6
Cd	524	0.01	23	2.7
Sn	0	-	-	-
Sb	1	-	-	0.05
Hg	169	0.02	2.4	0.39
Tl	0	-	-	-
Pb	392	0.01	21	1.03
Wet weight (TM RANGES WET):				
Cr	9	0.05	87	19
Ni	13	0.04	0.82	0.22
Cu	32	2.5	480	45
Zn	25	4.9	1430	450
As	6	0.07	0.78	0.27
Se	0	-	-	-
Ag	2	0.32	0.33	0.32
Cd	45	0.13	11	1.4
Sn	1	0	0	0.04
Sb	0	-	-	-
Hg	18	0.005	0.08	0.039
Tl	0	-	-	-
Pb	33	0.05	3.2	0.66

* Lowest reported concentration or detection limit.

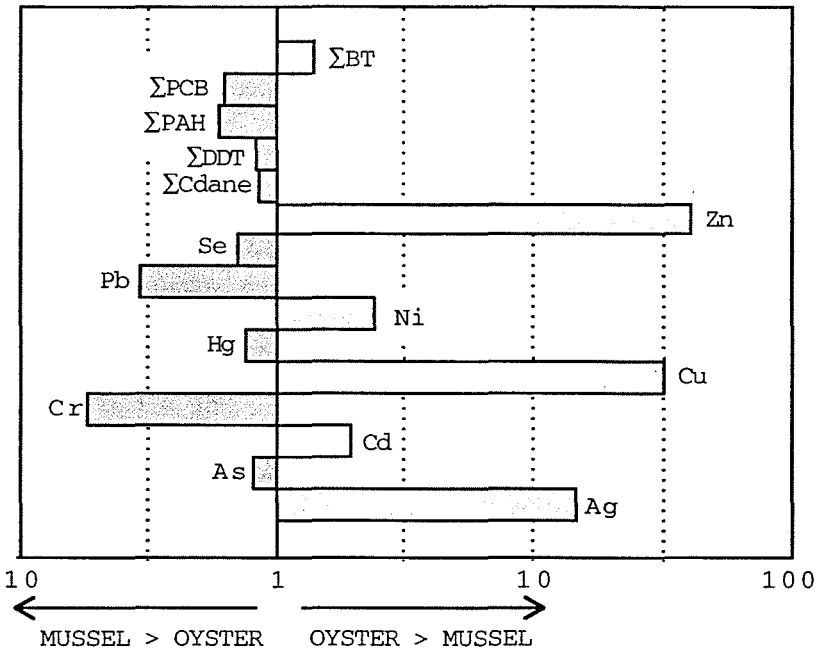

Figure 3. Factors by which mean concentrations in oysters (*C. virginica*) differ from those in mussels (*M. edulis*) collected at the NOAA NS&T Housatonic River site in Long Island Sound in 1989 (ΣBT is the sum of the concentrations of tributyltin and its breakdown products, dibutyltin and monobutyltin. ΣPCB is total PCB concentration calculated from the sum of the concentrations of the 18 congeners determined as part of the NS&T Program. ΣPAH is the sum of the concentrations of 24 PAHs. ΣDDT is the sum of the concentrations of DDT and its metabolites. ΣCdane is the sum of the concentrations of the two major constituents of chlordane mixtures, *cis*-chlordane and *trans*-nonachlor, and of those of two minor constituents, heptachlor and heptachlor epoxide.) (Redrawn from O'Connor, 1993).

There are some Cu and Zn data dating back to the turn of the century when there was an interest in the use of oysters in the treatment of anemia. The levels found back then were not the highest found in the literature, although the specimens analyzed were usually "green" oysters with known high levels of Cu.

No data were found for Se in oysters and very little for Se in mussels. The data appear to be log normal with a small concentration range.

The Ag and Hg data distributions do not clearly show log normal distributions, but low levels and analytical methodology could contribute to the data distribution pattern.

Most of the data found for Sn resulted from tributyltin studies in which the level of elemental Sn was reported. The analytical methodology for tributyltin and the units used for reporting results can vary from study to study. A more comprehensive study of Sn and tributyltin data would be needed to determine a global Sn level in mussels and/or oysters.

Little data were found for Sb and Tl and no conclusions could be made for these elements.

5. DISCUSSION

5.1. Mean values for mussels and oysters

The geometric means and "high" concentrations for Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Hg and Pb for the WMW data were calculated and are listed in Table 6. The "high" values are the mean plus one standard deviation of the logarithms of the data. The median and 85th percentile values for Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Hg and Pb for the WMW database were calculated and are listed in Table 7. The median or 50th percentile is the value below which 50% of the observations have a lower value. The 85th percentile is the value above which 85% of the values are found. Percentiles are robust with regard to both outliers and concentrations below the detection limit.

5.2. Comparison with long term Mussel Watch programs

The results of the WMW compilation were compared to those of two long-term Mussel Watch programs: the NS&T and RNO French Mussel Watch programs. The same data treatment used to calculate the mean, median and 85th percentile values of the WMW data was applied to the NS&T and RNO data, and the results are listed in Tables 6 and 7.

There is generally good agreement for geometric means and medians among all three data sets. The WMW "highs" tend to be higher than their NS&T and RNO counterparts. This is probably due to the fact that the latter two programs emphasize collecting mollusks at representative sites rather than within small areas of extreme contamination near waste discharges. Within the WMW compilation, on the other hand, are data from programs specifically designed to sample "hot spots" and these are evident at the upper end of the concentration distributions.

The mean, "high", median and 85th percentile concentrations for Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Hg and Pb for the WMW, NS&T and RNO data sets were calculated and are listed in Table 6. There is good agreement between the three sets of data for several elements. The WMW results appear to be higher in some cases. This can be explained by the inclusion of the very high levels found in oysters and mussels collected from contaminated sites. Elimination of these values lowers the mean and "high" values resulting in better agreement with NS&T results since the the NS&T sites do not include "hot spots". The RNO values appear to be the lower of the three sets of data. There is no explanation for this other than it being the result of analytical methodology differences between NS&T and RNO. As with the previous calculation, good agreements among the three sets of data were found.

5.3. Compilation of all data for mussels and oysters

As previously discussed in Section 4.5.3, mussels and oysters are not equal in their ability to concentrate trace elements. The differences for Cr, Ni, As, Se, Cd, Hg and Pb were not sufficiently high as to prevent the combination of the mussel and oyster data. The data for Cr, Ni, As, Cd, Hg and Pb in mussels and oysters in the WMW, NS&T and RNO databases were combined and the median, 85th percentile calculated (Table 8). The data are shown graphically in Appendix III. No Cr, Ni or As data were available from RNO. There were insufficient Se data in the WMW database to use meaningfully. The agreement between the medians and 85th percentiles of the three programs for some elements is very close. Some differences, such as the high median and 85% percentile for Pb, and high 85th percentile for Cd in the WMW, remain. Lower Pb levels in the NS&T data can be explained by the history of use (Beliaeff *et al.*, 1997).

Table 6. Comparison of WMW, NS&T and RNO mean and "high" concentrations (µg/g dry wt.). [All data used in calculations. NS&T data covers 1986 through 1995. RNO data covers 1979 through 1994.]

		Mussels			Oysters		
		Mean	"High"*	n	Mean	"High"	n
Cr	WMW	1.9	6.8	343	2.5	8.7	705
	NS&T	1.8	3.2	1854	0.55	1.2	1909
	RNO	-	-	-	-	-	-
Ni	WMW	2.5	5.8	776	1.8	6.4	320
	NS&T	1.9	3.5	1851	1.8	3.4	1940
	RNO	-	-	-	-	-	-
Cu	WMW	9.9	29	1877	140	680	1960
	NS&T	9.3	12	1854	120	300	1943
	RNO	7.2	9.3	3295	120	320	2796
Zn	WMW	130	340	2058	1400	5100	1726
	NS&T	130	180	1855	2000	4400	1944
	RNO	110	180	3297	1900	3800	2804
As	WMW	6.8	31	189	4.6	20	276
	NS&T	10	14	1855	9.2	17	1943
	RNO	-	-	-	-	-	-
Se	WMW	2.1	6.4	95	-	-	-
	NS&T	2.5	3.6	1830	2.7	3.9	1930
	RNO	-	-	-	-	-	-
Ag	WMW	0.26	1.1	440	1.2	3.0	250
	NS&T	0.15	0.67	640	2.1	5.0	813
	RNO	-	-	-	-	-	-
Cd	WMW	2.3	7.3	1982	4.6	19	1293
	NS&T	2.2	4.5	1854	3.0	6.3	1943
	RNO	1.0	1.9	3273	2.7	6.9	2793
Hg	WMW	0.40	1.9	942	0.30	0.78	541
	NS&T	0.13	0.25	1832	0.10	0.20	1926
	RNO	0.12	0.22	3154	0.19	0.32	2718
Pb	WMW	5.3	23	1804	2.3	8.6	947
	NS&T	1.9	5.0	1852	0.49	0.98	1927
	RNO	2.2	4.6	3265	1.4	2.5	2764

* High is defined as the mean plus one standard deviation on a logarithmic scale.
n = Non-zero values in the data sets.

Table 7. Comparison of WMW, NS&T and RNO median and 85 percentile concentrations (µg/g dry wt.). [All data used in calculations. NS&T data covers 1986 through 1995. RNO data covers 1979 through 1994.]

		Mussels			Oysters		
		Median	85th Percentile*	n	Median	85th Percentile	n
Cr	WMW	1.6	6.5	343	2.5	10	705
	NS&T	1.8	3.1	1854	0.55	1.2	1909
	RNO	-	-	-	-	-	-
Ni	WMW	2.2	5.0	776	2.2	4.7	320
	NS&T	1.9	3.5	1851	1.8	3.2	1940
	RNO	-	-	-	-	-	-
Cu	WMW	7.9	21	1877	160	680	1960
	NS&T	9.1	12	1854	120	280	1943
	RNO	7.1	9.1	3295	130	320	2796
Zn	WMW	130	260	2058	1600	4500	1726
	NS&T	130	190	1855	2100	4300	1944
	RNO	110	180	3297	2100	3500	2804
As	WMW	7.1	16	189	5.7	14	276
	NS&T	9.6	15	1855	7.9	18	1943
	RNO	-	-	-	-	-	-
Se	WMW	2.2	3.9	95	-	-	-
	NS&T	2.5	3.6	1830	2.7	3.9	1930
	RNO	-	-	-	-	-	-
Ag	WMW	0.25	1.0	440	1.3	2.6	250
	NS&T	0.15	0.72	640	2.1	5.1	813
	RNO	-	-	-	-	-	-
Cd	WMW	2.0	7.5	1982	4.1	21	1293
	NS&T	2.2	4.8	1854	3.2	6.0	1943
	RNO	0.95	1.9	3273	2.3	6.0	2793
Hg	WMW	0.32	0.99	942	0.27	0.70	541
	NS&T	0.12	0.26	1832	0.09	0.19	1926
	RNO	0.12	0.22	3154	0.20	0.32	2718
Pb	WMW	5.0	20	1804	2.5	8.6	947
	NS&T	1.8	5.1	1852	0.47	0.85	1927
	RNO	2.3	4.5	3265	1.4	2.4	2764

* The 85th percentile concentration is the one below which are the concentrations of 85% of the samples. The median concentration has half the samples with a lower concentration, and the other half with a higher concentration.
n = Non-zero values in the data sets.

Table 8. Comparison of WMW, NS&T and RNO median and 85 percentile combined mussel and oyster concentrations (µg/g dry wt.). [All data used in calculations. NS&T data covers 1986 through 1995. RNO data covers 1979 through 1994.]

		Median	85th Percentile*	n
Cr	WMW	2.1	9.5	1048
	NS&T	1.1	2.5	3763
	RNO	-	-	-
Ni	WMW	2.2	5.0	1096
	NS&T	1.9	3.4	3791
	RNO	-	-	-
As	WMW	6.3	15	465
	NS&T	9.1	16	3798
	RNO	-	-	-
Cd	WMW	2.6	12	3275
	NS&T	2.6	5.5	3797
	RNO	1.4	3.7	6066
Hg	WMW	0.30	0.87	1482
	NS&T	0.11	0.23	3758
	RNO	0.15	0.28	5872
Pb	WMW	4.0	16	2751
	NS&T	0.76	3.2	3779
	RNO	1.8	3.7	6029

* The 85th percentile concentration is the one below which are the concentrations of 85% of the samples. The median concentration has half the samples with a lower concentration, and the other half with a higher concentration.
n = Non-zero values in the data sets.

5.4. Changes in concentration with time

There were insufficient data found to determine if the trace metal levels in mussels and/or oysters have changed with time. Little data were found prior to the 1970s. During the 1970s, there was a significant increase in the number of citations reporting the use of mussels and oysters to determine contamination level and monitor coastal areas. Many of these studies included highly contaminated sites, resulting in very high trace metals values. The high values reported during the 1970s may be the result of increased awareness of coastal contamination and evaluation of contaminated sites, not necessarily of increased pollution levels. No evaluation of changes in trace metal levels in bivalves with time was possible.

5.5. Correlation of trace element level with longitude

An attempt was made to determine if the levels of some trace elements could be related to longitude. There is an overwhelming number of data points in Europe, the United States, Australia, New Zealand and Hong Kong resulting in an uneven geographical distribution of data points. Therefore, the attempt to correlate element concentration with longitude was unsuccessful.

5.6. Correlation of trace element level with local levels of contamination

The level of contamination of sampling sites, according to the authors of the citations, was entered in the WMW database. However, few of the citations had any indication as to contamination level. Also, many citations could not be found or the sampling site could not be accurately determined. Therefore, no attempt was made to use contamination level to eliminate "hot spot" data from the WMW database.

6. CONCLUSIONS

In the absence of human activity, there would be measurable concentrations of trace elements in mussels and oysters. We have no independent basis for declaring any specific concentration as a natural limit, but to a first approximation we could use the lowest of the 85th percentiles from the NS&T or RNO Mussel Watch programs as indicative of contamination (i.e., elevated by human activity). The WMW 85th percentiles include data from heavily contaminated sites and thus are not comparable to NS&T and RNO percentiles. The concentrations (from Table 8) in any mussel or oyster that would denote contamination are listed in Table 9.

There are mollusks with lower concentrations that are contaminated. Conversely, there are sites where local mineralogy causes mollusks to have higher concentrations of one or another of these trace elements and are not contaminated. Nonetheless, as a first approximation, these limits can be used for classifying concentrations reported by monitoring programs from around the world. Even without classifying, new data can be put into its worldwide context by comparing them with the data summarized here or by inserting them into the WMW database.

7. ACKNOWLEDGMENTS

The author wishes to thank the numerous chemists that produced the data over many years used to compile the GOOS WMW database, the Staff of the NOAA Central Library for their assistance in locating numerous citations, T. O'Connor for his suggestions, and D. Harris for scanning, proof reading, and his many, many trips to the library.

Table 9. Concentrations of trace metals in mussels and oysters that are indicative of contamination (µg/g dry wt.)

Metal	Concentration
Mussels and oysters	
Cr	2.5
Ni	3.4
As	16
Cd	3.7
Hg	0.23
Pb	3.2
Mussels	
Cu	10
Zn	200
Ag	0.75
Oysters	
Cu	300
Zn	4000
As	5

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APPENDIX I

World Mussel Watch Database Data Sources

NA - Not available.

Analytes in parenthesis denote those analytes listed in the data source but not included in the database.

Codes are internal identification numbers. Those with dashes such as "19-H-1" were assigned by Kidder (1977).

Acronyms are listed at the beginning of the document.

Data on a dry weight basis unless noted.

I.1. **1890 - 1900**

Year: **1895?**
Country: **Germany**

Source: **684**

Species: Oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Lehmann, K. B. (1895) Hygienische Studien über Kupfer. II. Der Kupfergehalt der menschlichen Nahrungsmittel. Arch. Hyg., Berlin, 24(-):18-72 (German).
This is a study of the Cu content of foods and animals. "Green" and normal oysters from Germany were analyzed for Cu and the concentrations reported. Results reported on a wet weight basis.

Year: **1896?**
Country: **England?**

Source: **427**

Species: Oysters
Number of sites: NA
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu

Paul, B. H., and A. J. Cownley (1896) The detection of copper in vegetable substances. Pharm. J., 2(-):441-2.
Oysters from four locations were analyzed for Cu content by carbonizing 100 g of tissue in a Pt container and extracting the ash with concentrated HCl, filtering through an acid-washed filter, washing the filter with hot water into a porcelain dish. The HCl-insoluble residue was treated with HNO_3, dried and ignited. The ignited mass was treated with HCl and the filtered solution added to the first portion. The HCl solution was concentrated in a tared Pt dish and Cu precipitated using pure Zn. Results reported on a wet weight basis.

I.2. **1901 - 1910**

Year: 1904, 1971
Country: Belgium

Source: 498 (72-B-1)

Species: *Mytilus edulis*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: Yes
Analytes: (Sc), (Co), Cr, (Fe), Zn, Se, Ag, Sb, Hg

Bertine, K. K., and E. D. Goldberg (1972) Trace elements in clams, mussels, and shrimp. Limnol. Oceanogr., 17(-):877-84.
Compositional changes in the trace element content of shells of mussels and clams that might be related to man's influence on the composition of inshore marine waters over the past hundred years were sought but not found. The elements Rb, Fe, Co, Sb, Sc, Ag, Cr, Zn, Se, and Hg were analyzed in freshly caught and museum specimens. Contamination from the preservatives was evident in the shells and tissues of museum specimens. Analysis done using NAA. NIST SRM 1b (Limestone) was used as part of the QA protocol.

Year: 1908?
Country: United States

Source: 178 (08-W-1)

Species: Oysters
Number of sites: 21
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Willard, J. T. (1908) On the occurrence of copper in oysters. J. A. C. S., 30(-):902-4.
Oysters were analyzed for Cu content after some cases of illness were reported as the result of eating greenish blue specimens. The tissues were digested using H_2SO_4 and the Cu deposited electrolytically. Some concentration means and ranges were reported.

I.3. **1911 - 1920**

Year: **1915?**
Country: **England?**

Source: **CAS1**

Species: Oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes:

Liebert, F. (1915) Turning green of oysters and their content of heavy metals. Chem. Weekblad, 12(-):978-83. [No copy of paper available. Information found in Chem. Abs., 10:1060, 1916.]
Green oysters from Truro were analyzed and the Cu content was found to be 0.244% Cu dry wt. and 0.08% Cu dry wt. The oysters with the lower concentrations had a less intense green color.

Year: **1915**
Country: **United States**

Source: **102 (19-H-1)**

Species: *Crassostrea virginica*
Number of sites:
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, As
NOTE: DATA REPORTED AS WET WEIGHT.

Hiltner, R. S., and H. J. Wichmann (1919) Zinc in oysters. J. Biol. Chem., 38(-):205-221.
In 1915, the presence of notable amounts of Zn in oysters was discovered almost simultaneously by two laboratories of the Department of Agriculture. A number of analysts from New York, Philadelphia, Boston and Denver determined the occurrence of Zn and Cu in oysters from various localities of the East Coast, and the relation of Zn in oysters to the level of Zn in the seawater in which they grew. The presence of Zn in oyster tissue was determined using various quantitative tests. All the analytical methods are well described in the paper. A composite sample of oysters was used. Organic matter in the sample was destroyed by an H_2SO_4 digestion. Copper in the resulting ash was separated from Zn as a sulfide by adding a slightly acid solution of hydrogen sulfide to the material. The filtrate was used for Zn determination using titration with potassium ferrocyanide. Results were reported on a wet weight basis.

Year: **1920?**
Country: **United States**

Source: **234 (20-B-1)**

Species: Oysters
Number of sites: NA
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Zn

Bodansky, M. (1920) Biochemical studies on marine organisms. II. The occurrence of zinc. J. Biol. Chem., 44(-):399-407.
This paper described a biochemical study to determine the level of Zn in various marine organisms. A comparison was made between the turbidimetric method used in the analyses and an earlier gravimetric method. Results reported on a wet weight basis.

Year: **1920?**
Country: **United States**

Source: **20-R-1**

Species: Oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Rose, W. C., and M. Bodansky (1920) Biochemical studies on marine organisms. I. The occurrence of copper. J. Biol. Chem., 44(-):99-112.
[INFORMATION IN KIDDER ONLY.] Analyses were done using colorimetry. Other species were also collected and analyzed. Results reported on a wet weight basis.

Year: **1922**
Country: **United States**

Source: **275**

Species: *Ostrea lurida*, other oysters and mussels
Number of sites:
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn

Severy, H. W. (1923) The occurrence of copper and zinc in certain marine animals. J. Biol. Chem., 55(-):79.
Specimens were collected along the Pacific coast and analyzed for Cu and Zn using methods previously used and described by others for such determinations in specimens collected in the Atlantic coast. The bivalve specimens were collected from local markets. Various other species as well as seawater were also analyzed. Results reported on a wet weight basis.

Year: **1924?**
Country: **England**

Source: **CAS3**

Species: *Ostrea edulis*
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Orton, J. H. (1924) An account of investigation into the cause or causes of the unusual mortality among oyster in English oyster beds during 1920 and 1921. Data mean and/or range reported on a wet weight basis. Fish. Invest., (2)6(3):199. (Quoted in Vinogradov, 1953.)
Copper concentrations were found to be 40 - 1000 µg/g wet wt.

Year: **1924**
Country: **United States?**

Source: **233 (24-M-1)**

Species: Oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), Cu, Zn

McHargue, J. S. (1924) The significance of the occurrence of copper, manganese and zinc in shell-fish. Science, 60(-):530. (Abstract only.)
Small amounts of the elements Cu, Mn and Zn are widely distributed in nature. The author found parts per million of Cu, Fe, Mn and Zn in the dry tissues of crayfish, clams, oysters, the edible meat of lobsters, and whole crabs. The author assumes that Cu, Mn and Zn are vitally concerned in the metabolism of shellfish and are probably vital factors in the metabolism of higher animals as well.

Year: **1925?**
Country: **England**

Source: **221**

Species: Mussels and oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Chapman, A. C., and H. Linden (1926) On the presence of compounds of arsenic in marine crustaceans and shell fish. Analyst, 51(-):548-63.
This paper discusses As compounds in various marine organisms and seawater. Results reported on a wet weight basis.

Year: 1925?
Country: France

Source: 488

Species: Mussels
Number of sites: NA
Analytical methodology?: Yes.
Quality assurance?: NA
Analytes: (Co), Ni

Bertrand, G., and M. Mâcheboeuf (1925) Sur la présence du nickel et du cobalt chez les animaux. C. R. Acad. Sci., Paris, 180(-):1380-3 (French).
This paper describes the analytical procedure used to determine levels of Co and Ni in various human and non-human tissues.

Year: 1927?
Country: England

Source: 222 (27-C-1)

Species: Mussels and oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Pb

Chapman, A. C., and H. Linden (1926) On the presence of lead and other metallic impurities in marine crustaceans and shell fish. Analyst, 51(-): 563-4.
Composite samples of about a dozen mussels were analyzed. "Portuguese" oysters were also analyzed. It is unclear whether these were oysters from Portugal or a name used for a type of oyster found locally.

Year: 1929?
Country: United States

Source: 683

Species: Oysters
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Lindow, C. W., C. A. Elvehjem, and W. H. Peterson (1929) The copper content of plant and animal foods. J. Biol. Chem., 82(-):465-71.
This paper lists the Cu content of various plant and animal foods.

I.5. **1931 - 1940**

Year: **1931**
Country: **United States**

Source: **333**

Species: Oysters
Number of sites: 13
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu

Coulson, E. J., H. Levine, and R. E. Remington (1932) Oysters and anemia. Am. J. Pub. Health, 22(-):1141-6.
Oysters from the East and Gulf coasts of the United States were analyzed for mineral content. Oysters were shipped to the laboratory on ice. The specimens were dried and ground. Results reported on a wet weight basis.

Year: **1931?**
Country: **United States**

Source: **394**

Species: Oysters
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu

Hodges, M. A., and W. H. Peterson (1931) Manganese, copper and iron content of serving portions of common foods. J. Am. Dietetic Assoc., 7(-):6-16.
This paper contains a table of the Mn, Fe, and Cu content of foods. Results reported on a wet weight basis.

Year: **1931?**
Country: **United States**

Source: **355**

Species: Oysters
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu

Levine, H., and R. E. Remington (1931) The value of the oyster in nutritional anemia. J. of Nutrition, 4(4):469-81.
The value of oysters as a source of minerals was discussed in this paper. The oysters analyzed for the nutrition study were collected in South Carolina.

Year: **1931 - 1932**
Country: **United States**

Source: **224**

Species: Oysters
Number of sites: 26
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu

Coulson E. J. (1933) Studies on the nutritive value of oysters. Inv. Rep. 17, U. S. Dept. of Commerce, Bureau of Fisheries. 1-30.
Oysters and other marine species were analyzed to determine their suitability in the treatment of nutritional anemia. Oysters were obtained from many locations along the United States coasts and shipped to the laboratory alive.

Year: 1932?
Country: United States
Source: 117

Species: Oysters
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Galstoff, P. S. (1934) The biochemistry of the invertebrates of the sea. Ecol. Monographs, 4(-):481-90 (CA, 28:7274, 1934)
The levels of Cu in oysters were 72 - 432 µg/g dry wt. Data mean and/or range reported on a dry weight basis.

Year: 1938?
Country: United States
Source: 38-M-1

Species: *Mytilus edulis*
Number of sites: 2?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Marks, G. W. (1938) The copper content and copper tolerance of some species of mollusks of the Southern California coast. Biol. Bull., 75:224-37.
[INFORMATION IN KIDDER ONLY.] Analyses were done using colorimetry. Other species were collected and analyzed.

Year: 1938?
Country: United States
Source: 219

Species: *Ostrea lurida, Crassostrea virginica*
Number of sites: NA
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Cu, (I)

Nilson, H. W., and E. J. Coulson (1939) The mineral content of the edible portions of some American fishery products. Invest. Rep. U. S. Bur. Fish, 41(-):1-7.
Oysters from the East and West coasts of the United States were analyzed for mineral content. Results reported on a wet weight basis.

Year: 1939
Country: Australia
Source: 220

Species: *Mytilus obscurus, Saccostrea commercialis*
Number of sites: NA
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Na), (Mg), (P), (S), (K), (Ca), (Mn), (Fe), Cu

Clements, F. W., and R. C. Hutchinson (1939) The ash constituents of Australian fish. Aust. J. Exp. Biol. Med. Sci., 17(1):89-92.
The paper reports data on elemental content of Australian fish and shellfish obtained from local markets.

I.6. **1941 - 1950**

Year: **1948?**
Country: **Russia**
Source: **CAS5**

Species: *Mytilus edulis*
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Gorgy, S., N. W. Rakestraw, and D. L. Fox (1948) Arsenic in the sea. J. Mar. Res., 7():22-32.
[No copy of the paper available.] Results reported on a wet weight basis.

I.7. **1951 - 1960**

Year: **1953**
Country: **United States**
Source: **541**

Species: *Crassostrea virginica*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn

Galtsoff, P. S. (1953) Accumulation of manganese, iron, copper, and zinc in the body of American oyster, *Crassostrea* (Ostrea) *virginica*. Anat. Rec., 117(-):601.
Bi-weekly observations on 4- to 5-year-old oysters taken from one commercial bed in New England showed that during a period of 18 months, the concentrations of the four metals studied was higher in June - October and lower in November - May. Samples were composites of 10 individuals. Data mean and/or range reported on a dry weight basis.

Year: **1953?**
Country: **Mexico**
Source: **CAS4**

Species: Oysters
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Giral, J., and M. T. Castillo (1953) Determination of copper in Mexican foods. Mem. Congr. Cient. Nex., IV Centenario Univ. Mexico, 2(-):232-4.
[No copy of the paper available.] Results reported on a wet weight basis.

Year: **1954 - 1956**
Country: **Japan**
Source: **699**

Species: *Ostrea gigas*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Al, (Mn), (Fe), Cu, Zn, Pb

Hayashi, A. (1961) Biochemical studies on trace elements in Magaki (*Ostrea gigas*). I. Seasonal variation in meat. J. Sci. Hiroshima Univ., Ser. A-II, 25(2):337-45.
The seasonal variation of the content of various elements in oyster tissue was studied for a year and four months. The seasonal variation was found to be related to the physiological condition of the oysters. Oysters grown under various cultivation methods were shucked and washed in distilled water. The tissues were ashed and analyzed using polarographic and colorimetric methods.

Year: 1955
Country: Spain
Source: 687

Species: *Mytilus edulis*
Number of sites: 10
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Pb

López Costa, R., L. Rodríguez Molíns, and J. R. Besada Rial (1957) Estudio químico sobre el mejillón (*Mytilus edulis*) de la ría de Vigo: Determinación colorimetrica del plomo en el mejillón (*Mytilus edulis*) y en el agua de mar de la ría de Vigo. Bol. Inst. Esp. Oceanogr., -(87):1-18 (Spanish).
Samples of Mytilus edulis and seawater were collected from various sites at the Ría de Vigo, Spain. The analytical methods used are described in detail.

Year: 1956?
Country: Peru
Source: CAS2

Species: *Mytilus magellanicus*
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Moyano, C. (1956) Arsenic content of several shellfish of the Peruvian coast. Bol. Soc. Quim. Peru, 22(-):5-16. [No copy of paper available. Information found in Chem. Abs., 51:2193a, 1957.]
Arsenic levels were 1.05 - 2.61 µg/g wet wt. Data mean and/or range reported on a wet weight basis.

Year: 1957?
Country: England?
Source: 276 (58-C-2)

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Al), (Fe), Cu, (Ga)

Culkin, F., and J. P. Riley (1958) The occurrence of gallium in marine organisms. J. Mar. Biol. Assoc. U. K., 37(3):607-15.
The concentrations of Ga in various marine organisms, including the blue mussel, are reported in this paper. Tissue samples were digested in HNO_3, $HClO_4$ and H_2SO_4 and the ashes dissolved in 1% $SnCl_2$ in 6.5 N HCl. Gallium was extracted from the digestates into di-*iso*-propyl ether. The elements were determined using spectrometric methods described in cited papers.

Year: 1957
Country: Japan
Source: 698

Species: *Ostrea gigas*
Number of sites: 10
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Pb

Hayashi, A. (1961) Biochemical studies on the trace elements in *Magaki* (*Ostrea gigas*) II. Distribution in different parts of meat. J. Sci. Hiroshima Univ. Ser. A-II, 25(2):347-50.
The content and distribution of Mn, Fe, Cu, Zn and Pb in adductor, mantle, gills, and viscera of oysters were studied and differences were found in the content of each organ. Only the concentrations found in the whole body were added to the database.

Year: 1960
Country: United States

Source: 92 (61-M-1)

Species: Oysters and mussels
Number of sites: 14
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

McFarren, E. F., J. E. Campbell, and J. B. Engle (1961) The occurrence of copper and zinc in shellfish. Proc., Shellfish Sanitation Workshop. Jensen, E. T., (ed.), November 28-30, 1961. United States Dept. of Health, Education, and Welfare, Washington, DC, 229-34 (Appendix R). Oysters and mussels were collected in Chesapeake and Delaware Bays and analyzed for Cu and Zn.

I.8. **1961 - 1970**

Year: **1962**
Country: **Monaco?**

Source: **65-F-3**

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr

Fukai, R. (1965) Analysis of trace amounts of chromium in marine organisms by the isotope dilution of ^{51}Cr. In: Radiochemical Methods of Analysis, Vol. 2. IAEA, Vienna, Austria. 335-51. [INFORMATION IN KIDDER ONLY.] Analysis were done using isotope dilution.

Year: **1962 - 1964**
Country: **France, Monaco**

Source: **65-F-2**

Species: *Mytilus edulis, Gryphaea angulata*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Fe)

Fukai, R., and D. Broquet (1965) Distribution of chromium in marine organisms. Bull. Inst. Oceanogr. Monaco, 65(1336):1-19.
[INFORMATION IN KIDDER ONLY.] Analyses were done using isotope dilution.

Year: **1964**
Country: **Portugal**

Source: **65-V-1**

Species: *Crassostrea angulata*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Vilela, H. (1965) Exploraçao e salubridade de moluscos testaceos marinhos en 1964. Boletim da Pesca, 86(-):23-45 (Portuguese).
[INFORMATION IN KIDDER ONLY.] Specimens were collected in the Tajo and Sado estuaries. Data mean and/or range reported on a wet weight basis.

Year: **1964 - 1965**
Country: **United States**

Source: **69-K-1**

Species: Oysters
Number of sites: 10?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Kopfler, F. C., and J. Mayer (1969) Studies on trace metals in shellfish. Proc. Gulf and South Atlantic States Shellfish Sanitation Research Conf., Mobile, AL, March 21-22, 1967. R. J. Hammerstorm and W. F. Hill, eds. UH HEW, CIncinnati, OH. 67-80.
[INFORMATION IN KIDDER ONLY.] Results reported on a wet weight basis.

Year: 1965
Country: Japan
Source: 67-I-1

Species: *Ostrea gigas, Ostrea spinosa, Ostrea circumpicta*
Number of sites: 10
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Ikuta, K. (1967) Studies on accumulation of heavy metals in aquatic organisms - I. On the copper contents in oysters. Bull. Jap. Soc. Sci. Fish., 33(-):405-9.
[INFORMATION IN KIDDER ONLY.] Specimens were collected in Nobeoka Bay. Results reported on a wet weight basis.

Year: 1965
Country: Japan
Source: 68-I-1

Species: *Ostrea gigas*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Ikuta, K. (1968) Studies on accumulation of heavy metals in aquatic organisms - II. On accumulation of copper and zinc in oysters. Bull. Jap. Soc. Sci. Fish., 34(-):112-6.
[INFORMATION IN KIDDER ONLY.] Specimens were collected in Urashiro Bay and Akamizu Inlet. Results reported on a wet weight basis.

Year: 1965?
Country: New Zealand
Source: 922 (65-B-1)

Species: *Ostrea sinuata, Mytilus edulis aoteanus*
Number of sites: 6
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (V), Cr, (Mn), (Fe), Ni, Cu, Zn, (Mo), Ag, Cd, Pb

Brooks, R. R., and M. G. Rumsby (1965) The biogeochemistry of trace element uptake by some New Zealand bivalves. Limnol. Oceanogr., 10(-):521-8.
This is a study of the biogeochemistry of trace element updake by marine elements and of the pathways involved. The bivalve specimens were shucked, rinsed and dried. The tissue was ashed and the elements determined using d-c arc spectroscopy. Sediment and *Pecten novae-zelandiae* were also collected and analyzed.

Year: 1965
Country: Portugal
Source: 66-V-1

Species: *Crassostrea angulata*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Vilela, H. (1966) Exploraçao e salubridade de moluscos testaceos marinhos, 1965. Boletim da Pesca, 90(-):11-42 (Portuguese).
[INFORMATION IN KIDDER ONLY.] Specimens were collected in the Tajo and Sado estuaries. Data mean and/or range reported on a wet weight basis.

Year: 1965 - 1967
Country: United States

Source: 94 (68-P-2)

Species: *Crassostrea gigas, Crassostrea virginica*
Number of sites: 100
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), Co, Ni, Cu, Zn, Cd, Pb

Pringle, B. H., D. E. Hissong, E. L. Katz, and S. T. Mulawka (1968) Trace metal accumulation by estuarine mollusks. J. Sanit. Eng. Div., Proc. Amer. Soc. Civil Eng., 94(-):455-75.
Approximately 100 stations in the East and West coasts of the United States were sampled. The samples were homogenized, lyophilized, wet digested, diluted and analyzed using AAS. Data on other species also available. Data mean and/or range reported on a wet weight basis.

Year: 1966
Country: Japan

Source: 68-I-2

Species: *Ostrea gigas*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Ikuta, K. (1968) Studies on accumulation of heavy metals in aquatic organisms - IV. On disappearance of abnormally accumulated copper and zinc in oysters. Bull. Jap. Soc. Sci. Fish., 34(-):482-7.
[INFORMATION IN KIDDER ONLY.] Specimens were collected in Urashiro Bay. Results reported on a wet weight basis.

Year: 1966
Country: Portugal

Source: 67-V-1

Species: *Crassostrea angulata*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Vilela, H. (1967) Exploraçao e salubridade de moluscos testaceos marinhos en 1966. Boletim da Pesca, 95(-):23-71 (Portuguese).
[INFORMATION IN KIDDER ONLY.] Specimens were collected in the Tajo and Sado estuaries. Data mean and/or range reported on a wet weight basis.

Year: 1966?
Country: United States

Source: 66-S-1

Species: Oysters
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Schroeder, H. A., and J. J. Balassa (1966) Abnormal trace metals in man: arsenic. J. Chronic Dis., 19:85-106.
[INFORMATION IN KIDDER ONLY.] Results reported on a wet weight basis.

Year: 1966 - 1967
Country: Spain
Source: 69-E-2

Species: *Crassostrea angulata*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Establier, R. (1969) Estudios del contenido en cobre del agua de mar y ostiones (*Crassostrea angulata*) de las costas de Cádiz. Inv. Pesq., 33(-):69-86 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using colorimetry and spectrophotometry.

Year: 1966 - 1969
Country: Spain
Source: 71-E-1

Species: *Crassostrea angulata*
Number of sites: 5
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Establier, R. (1971) Estudios sobre la acumulación del cobre en el ostion, *Crassostrea angulata* (Lmk). Pub. Tecn. Dir. Gen. Pesca Marit., -(9):231-6 (Spanish).
[INFORMATION IN KIDDER ONLY.] This was a transplantation study and only initial concentrations were included in the database. Analysis was done using AAS.

Year: 1966 - 1970
Country: Spain
Source: 72-E-2

Species: *Crassostrea angulata*
Number of sites: 7
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu

Establier, R. (1972) Nota sobre el contenido en cobre de los ostiones (*Crassostrea angulata*) de las coastas de Huelva. Inv. Pesq., 36(-):293-6 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using spectrophotometry.

Year: 1967 - 1968
Country: Spain
Source: 68-R-1

Species: *Mytilus edulis, Ostrea edulis*
Number of sites: 3
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

del Riego, A. F. (1968) Determinación del arsenico en los organismos marinos. Bol. Inst. Esp. Oceanogr., 134(-):-.
[INFORMATION IN KIDDER ONLY.]

Year: 1968 - 1969
Country: Spain
Source: 69-E-1

Species: *Crassostrea angulata*
Number of sites: 9
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn

Establier, R. (1969) Contenido en cobre, hierro, manganeso y cinc en los ostiones (*Crassostrea angulata*) de las costas de Cádiz. Inv. Pesq., 33(-):335-45 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1968 - 1969
Country: Spain
Source: 74-E-1

Species: *Crassostrea angulata*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn

Establier, R., and E. Pasqual (1974) Estudios del cobre, hierro, manganeso y cinc en ostiones (*Crassostrea angulata*) del golfo de Cádiz. Inv. Pesq., 38(-):371-84 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1968 - 1969
Country: United States
Source: 73-K-2

Species: *Crassostrea virginica*
Number of sites: 8
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Pb

Kopfler, F. C., and J. Mayer (1973) Concentrations of five trace metals in the waters and oysters (*Crassostrea virginica*) in Mobile Bay, Alabama. Proc. Shellfish. Assoc., 63(-):27-34.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Only Cd data available and in database. Data mean and/or range reported on a wet weight basis.

Year: 1970
Country: Norway
Source: 70-L-1

Species: *Mytilus edulis, Ostrea edulis*
Number of sites: 1 (mussels) and 1 (oysters)
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As, Se

Lunde, G. (1970) Analysis of arsenic and selenium in marine raw materials. J. Sci. Food. Agr., 21(5):242-7.
[INFORMATION IN KIDDER ONLY.] Analysis done using NAA.

Year: 1970 - 1971
Country: England
Source: 74-L-1

Species: *Mytilus edulis, Ostrea edulis, Crassostrea angulata*
Number of sites: 3 (mussels) and 3 (oysters)
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As, Cd, Sb, Hg

Leatherland, T. M., and J. D. Burton (1974) The occurrence of some trace metals in coastal organisms with particular reference to the Solent region. J. Mar. Biol. Assoc. U. K., 54():457-68.
[INFORMATION IN KIDDER ONLY.] Other species were also analyzed.

Year: **1970 - 1973**
Country: **England, France, Wales**

Source: **456**

Species: *Mytilus edulis, Crassostrea gigas, Ostrea edulis, Crassostrea angulata*
Number of sites: 68?
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Hg, Pb. PCBs. Pesticides.

Portmann, J. E. (1979) Chemical monitoring of residue levels in fish and shellfish landed in England and Wales during 1970-73. Aquatic environment monitoring response no. 1, MAFF Directorate of Fisheries Research, Lowestoft, UK, 70 pp.
This is the first report of a series recording the results of the fish and shellfish monitoring program. Location of sites listed only as ICES rectangles. Results reported on a wet weight basis.

Year: **1971**
Country: **Australia**

Source: **182 (74-E-2)**

Species: *Mytilus edulis, Ostrea angasi*
Number of sites: 1 (mussels) and 1 (oysters)
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), Cu, Zn, Cd

Eustace, I. J. (1974) Zinc, cadmium, copper and manganese in species of finfish and shellfish caught in the Derwent Estuary, Tasmania. Aust. J. Mar. Freshwater Res., 25(-):209-20.
Thirty-nine marine species including members of the Teleostomi and Elasmobranchii, were obtained from the River Derwent, Tasmania, and analyzed for four heavy metals known to be accumulated by certain species, primarily mollusks. Tissues were digested using HNO_3, H_2SO_4 and $HClO_4$, and the subsequent solutions analyzed for Zn, Cu, and Mn using flame AAS. Aliquots of the digestate were extracted using sodium diethyldithiocarbamate and MIBK, and the extracts analyzed for Cd content using flame AAS.

Year: **1971**
Country: **England**

Source: **252**

Species: *Mytilus edulis*
Number of sites: 19
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Zn, Cd, Pb

Nickless, G., R. Stenner, and N. Terrille (1972) Distribution of cadmium, lead and zinc in the Bristol Channel. Mar. Pollut. Bull., 3(12):188-90.
Specimens of *Mytilus edulis* were collected in 19 sites along the northern side of the Bristol Channel, and the islands of Steepholm and Flatholm. Tissue samples were digested using HNO_3 and the subsequent digestates analyzed using AAS. Other species were also collected and analyzed.

Year: **1971**
Country: **England, Wales**

Source: **496 (74-B-1)**

Species: *Crassostrea gigas*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), (Co), Ni, Cu, Zn, Cd, Pb

Boyden, C. R., and M. G. Romeril (1974) A trace metal problem in pond oyster culture. Mar. Pollut. Bull., 5(-):74-8.
Oysters reared in power station cooling water were found to have accumulated high concentrations of Cu and Zn. The reasons for such elevated metal concentrations and the relevance of these observations to shellfish culture have been examined and emphasize the care that must be taken to avoid unwitting contamination of culture ponds. Samples were digested using HNO_3 and the digestates analyzed using AAS.

Year: 1971?
Country: Ireland
Source: 177 (71-S-2)

Species: *Modiolus modiolus, Mytilus edulis*
Number of sites: 2?
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Al), (P), (Na), (Mg), (K), (Ca), Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, (Sr), Ag, Cd, Pb

Segar, D. A., J. D. Collins, and J. P. Riley (1971) The distribution of the major and some minor elements in marine animals. Part II. Molluscs. J. Mar. Biol. Assoc. U. K., 51(1):131-6.
Six major and 13 trace elements in 11 species of mollusks from the Irish Sea and one fresh water species were determined.

Year: 1971
Country: Spain
Source: 72-E-1

Species: *Crassostrea angulata*
Number of sites: 3
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Establier, R. (1972) Concentración de mercurio en los tejidos de algunos peces, moluscos y crustáceos del golfo de Cádiz y caladeros del noroeste africano. Inv. Pesq., 36(-):355-64 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1971?
Country: United States
Source: 93 (71-G-1)

Species: *Mytilus edulis, M. californianus*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), Cu, Zn, Ag, Cd, Pb

Graham, D. L. (1971) Trace metal levels in intertidal mollusks of California. Veliger, 14():365-72.
Determination of trace metals collected in California was done on seven species of Mollusca including two species of mussels. Separate analyses were performed on shells and soft portions of whole bodies. The specimens were depurated, shucked, and dried. The samples were digested using HNO_3 and HCl. If lipids were observed, H_2O_2 was added. Analysis done using AAS.

Year: 1971
Country: United States
Source: 72-W-1

Species: *Crassostrea virginica*
Number of sites: 10
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Fe), (Mn), Cu, Zn, Ag

Windom, H. L., and R. J. Smith (1972) Distribution of iron, magnesium, copper, zinc, and silver in oysters along the Georgia coast. J. Fish. Res. Bd. Can., 29(-):450-2.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1971
Country: Wales
Source: 72-C-2

Species: *Ostrea edulis*
Number of sites: 8
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Na), (K), (Ca), (Mg) (P), Cu, Zn

Coombs, T. L. (1972) The distribution of zinc in the oyster *Ostrea edulis* and its relation to enzymatic activity and to other metals. Mar. Biol., 12(-):170-8.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS and flame emission spectroscopy. Results reported on a wet weight basis.

Year: 1971
Country: Yugoslavia
Source: 71-S-1

Species: *Ostrea edulis, Mytilus galloprovincialis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Strohal, P., and M. Dzajo (1971) Concentration of mercury in the North Adriatic biota. Thalassia Jugosl., 7(-):591-6.
[INFORMATION IN KIDDER ONLY.] Analysis was done using NAA.

Year: 1971, 1980, 1983
Country: England
Source: 882

Species: *Ostrea edulis*
Number of sites: 2
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn

Bryan, G. W., P. E. Gibbs, L. G. Hummerstone, and G. R. Burt (1987) Copper, zinc, and organotin as long-term factors governing the distribution of organisms in the Fal Estuary in Southwest England. Estuaries, 10(3):208-19.
There is evidence of long-term contamination of the Fal Estuary. Indications are, however, that levels of Cu from mining declined but that levels of Zn have not. Oysters were allowed to depurate, and were then shucked and dried. The tissue samples were digested using HNO_3 and HCl, and the digestates analyzed using AAS. Cockles were also collected and analyzed as part of this work.

Year: 1971 - 1972
Country: Australia
Source: 917 (73-H-2)

Species: *Crassostrea commercialis*
Number of sites: 7
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Hussain, M., and E. L. Bleiler (1973) Mercury in Australian oysters. Mar. Pollut. Bull., 4(3):44.
There have been allegations that cultivated oysters from Botany Bay and Georges River, New South Wales, were contaminated by Hg. Low levels of Hg were found in the oysters collected for this study. Analysis done using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1971 - 1972
Country: Belgium

Source: 73-F-5

Species: Mussels
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Fouassin, A., A. Fontaine, and A. Noirfalise (1973) Le mercure dans les poissons et crustaces consommes en Belgique. Arch. Belg. Med. Soc. Hyg. Med. Trav. Med. Leg., 31(-):145-52 (French).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Data mean and/or range reported on a wet weight basis.

Year: 1971 - 1972
Country: Korea

Source: 259 (73-W-5)

Species: *Mytilus edulis, Crassostrea gigas*
Number of sites: 3 (mussels) and 4 (oysters)
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Cd, Hg, Pb

Won, J. H. (1973) The concentration of mercury, cadmium, lead and copper in fish and shellfish of Korea. Bull. Korean Fish. Soc., 6(1-2):1-19 (Korean).
Heavy metals were determined in fish and shellfish collected in Korea in 1971 and 1972.

Year: 1971 - 1973
Country: Mexico

Source: 76-C-3

Species: *Crassostrea gigas*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Pb

Chow, T. J., C. B. Snyder, H. G. Snyder, and J. L. Earl (1976) Lead content of some marine organisms. J. Environ. Sci. Health, A11(-):33-44.
[INFORMATION IN KIDDER ONLY.] Analysis done using MS. Lead levels in various organs and shells also listed in the paper. Other species were also analyzed.

Year: 1971 - 1973
Country: United States

Source: 75-F-2

Species: *Crassostrea virginica*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Cd

Frazier, J. M. (1975) The dynamics of metals in the American oyster, *Crassostrea virginica*. I. Seasonal effects. Ches. Sci., 16(-):162-75.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1971 - 1977
Country: Canada
Source: 446

Species: *Crassostrea gigas, Mytilus edulis*
Number of sites: 16
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Fe), Ni, Cu, Zn, As, Cd, Hg, Pb

Harbo, R. M., I. K. Birtwell, and O. E. Langer (1983) Trace metals in marine organisms from coastal waters of southern British Columbia. Rep. Fish. Aquatic Sci. 169, Dept. of Fisheries and Oceans, Vancouver, British Columbia, Canada. 42 pp.
Trace metal concentrations were determined in a variety of organisms collected in the southern coastal waters of British Columbia. Samples were frozen prior to analysis. Tissues were digested using HNO_3 and the metals concentrated from the digestates using APDC - 2-heptanone liquid extractions for Pb, Ni and Cd, and APDC - MIBK for some Pb extractions. No extractions were required for Cu, As and Fe. The solutions were analyzed using AAS. Tissues for Hg analyzed were digested using H_2SO_4 and oxidized using H_2O_2. Potassium permanganate was then added. The Hg was reduced using $SnCl_2$ or $SnSO_4$, swept by Ar into an AAS. Some data reported on a wet weight basis.

Year: 1972
Country: Australia
Source: 73-T-3

Species: *Crassostrea gigas, Ostrea angasi*
Number of sites: 8
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd

Thrower, S. J., and I. J. Eustace (1973) Heavy metals in Tasmanian oysters. Aust. Fish., 32(10):7-10.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Results reported on a wet weight basis.

Year: 1972
Country: Australia
Source: 73-T-1

Species: *Crassostrea gigas, Ostrea angasi*
Number of sites: 20
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd

Thrower, S. J., and I. J. Eustace (1973) Heavy metal accumulation in oysters grown in Tasmanian waters. Food Tech. Aust., 25:546-53.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1972
Country: Canada
Source: 74-F-3

Species: *Crassostrea virginica*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Freeman, H. C., D. A. Horne, B. McTague, and M. McMenemy (1974) Mercury in some Canadian Atlantic coast fish and shellfish. J. Fish. Res. Bd. Can., 31(-):369-72.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1972?
Country: England, Northern Ireland, Wales
Source: 212 (72-P-1)

Species: *Mytilus edulis, Ostrea edulis*
Number of sites: 20
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Portmann, J. E., and J. D. Yardley (1972) The distribution of some metals in shellfish taken from the coasts of England and Wales. ICES-CM-1972/K:12, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 5 pp.
The objective of this survey of trace metals in shellfish was to determine the concentrations in samples taken from all commercially important shellfish stocks. Analyses were conducted using pooled samples of 25 specimens. Samples were digested in HNO_3 and the digestates analyzed using AAS. Data mean and/or range reported on a wet weight basis.

Year: 1972
Country: Germany
Source: 147

Species: *Mytilus edulis*
Number of sites: 2
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Pb

Schulz-Baldes, M. (1974) Lead uptake from sea water and food and lead loss in the common mussel *Mytilus edulis.* Mar. Biol., 25(-):177-93.
The mechanism of Pb uptake in the blue mussels was studied using specimens collected from buoys in the River Weser, near Bremerhaven. The Pb content of various organs as well as whole soft tissues was determined. Lead determinations in digested tissue was done using GFAAS.

Year: 1972
Country: Norway
Source: 74-A-1

Species: *Mytilus edulis, Modiolus modiolus*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Andersen, A. T., and B. B. Neelakantan (1974) Mercury in some marine organisms from the Oslofjord. Norwegian J. Zool., 22(-):231-5.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1972
Country: Norway
Source: 126 (77-L-1)

Species: *Mytilus edulis*
Number of sites: 8
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Fe), Ni, Cu, Zn, Ag, Cd

Lande, E. (1977) Heavy metal pollution in Trondheimsfjorden, Norway, and the recorded effects on the fauna and flora. Environ. Pollut., 12(3):187-98.
The extent of heavy metal pollution in Trondheimsfjorden was investigated throughout the period 1972 - 1973. Samples of invertebrates and seaweeds from the intertidal zone were collected for analysis, and parts of some pelagic and bottom-dwelling fishes were also sampled. Samples were digested using $HClO_4$ and HNO_3, and the digestates were analyzed using flame AAS. Cadmium was determined using anodic stripping voltametry on a polarograph with a hanging mercury drop electrode.

Year: 1972
Country: Norway
Source: 921 (74-S-3)

Species: *Mytilus edulis*
Number of sites: 14
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb

Stenner, R. D., and G. Nickless (1974) Distribution of some heavy metals in organisms in Hardangerfjord and Skjerstadfjord, Norway. Water, Air Soil Pollut., 3:279-91.
Metal bearing waters enter the Sorfjord, a tributary of the Hardangerfjord. Unusually high concentrations of Cd, Pb, and Zn are present in marine life over a considerable length of the fjord. Bivalves were shucked and digested using HNO3. Analysis done using AAS. Other species and sediment were also collected and analyzed.

Year: 1972?
Country: Scotland
Source: 392

Species: *Mytilus edulis*
Number of sites: 17
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Topping, G. (1972) Heavy metals in shellfish from Scottish waters. ICES-CM-1972/E:21, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 7 pp.
Homogenates of edible tissues of various shellfish and individual parts were prepared and frozen. None of the shellfish examined contained trace metal concentrations which could be classified as toxic.

Year: 1972
Country: Spain
Source: 73-E-3

Species: *Mytilus edulis*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Establier, R. (1973) Contenido en mercurio de los mejillones (*Mytilus edulis*) silvestres y cultivados de la zona noreste española. Inv. Pesq., 37(-):101-6 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1972
Country: Mexico, United States
Source: 76-C-2

Species: *Mytilus edulis, Mytilus californianus*
Number of sites: 18
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Pb

Chow, T. J., H. G. Snyder, and C. B. Snyder (1976) Mussels as an indicator of lead pollution. Sci. Total Environ., 6(-):55-63.
[INFORMATION IN KIDDER ONLY.] Analyses done using MS. Lead content of various organs also listed in the paper.

Year: 1972
Country: Portugal, Spain
Source: 817 (75-S-1)

Species: *Mytilus edulis, Crassostrea angulata*
Number of sites: 8
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Stenner, R. D., and G. Nickless (1975) Heavy metals in organisms of the Atlantic coast of S.W. Spain and Portugal. Mar. Pollut. Bull., 6(-):89-92.
Various organisms from the southwest coast of Spain and Portugal were analyzed for Cu, Zn, Cd, and Pb. Samples were digested using HNO_3 and the subsequent digestates analyzed using AAS. Samples other than bivalves were also analyzed for Hg. Sediment, water samples, and other species were also analyzed.

Year: 1972
Country: Thailand
Source: 655

Species: *Mytilus viridis*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb. PCBs. DDTs. Pesticides.

Huschenbeth, E., and U. Harms (1975) On the accumulation of organochlorine pesticides, PCB and certain heavy metals in fish and shellfish from Thai coastal and inland waters. Arch. Fisch. Wiss., 2(3):109-22.
This is a baseline study of the levels of trace metals, PCBs and organochlorine pesticides in various species of fish and shellfish collected in Thailand. Tissues were dissolved using HNO_3 and $HClO_4$, the digestates analyzed using AAS and GFAAS. Results reported on a wet weight basis.

Year: 1972
Country: United States
Source: 229 (74-V-1)

Species: *Crassostrea virginica, Modiolus demissus*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Zn, Cd, Pb

Valiela, I., M. D. Banus, and J. M. Teal (1974) Response of salt marsh bivalves to enrichment with metal-containing sewage sludge and retention of lead, zinc and cadmium by marsh sediments. Environ. Pollut., 7(-):149-57.
The growth of *Mercenaria mercenaria* and *Crassostrea virginica* found in tidal creeks in salt marshes on the coast of the northeast Atlantic was not affected by experimental additions of metal-containing sewage sludge and urea fertilizers to salt marsh plots. Only the initial trace metal concentrations in this exposure study were added to the database. *Mercenaria mercenaria* was also analyzed as part of this study.

Year: 1972 - 1974
Country: Spain

Source: 75-E-4

Species: *Crassostrea angulata*
Number of sites: 5
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cd

Establier, R. (1975) Concentración de cadmio en organismos marinos de la costa sudatlántica española. Inf. Tecn. Inst. Inv. Pesq., 26(-):1-8 (Spanish).
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Range data in canned foodstuffs only. Data not in database.

Year: 1972 - 1974
Country: United States

Source: 74-F-6

Species: *Crassostrea virginica*
Number of sites: 6
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), Cu, Zn, Cd, Hg

Feng, S. Y., and G. M. Rudy (1974) Zn, Cu, Cd, Mn and Hg in oysters along the Connecticut coast. In: investigations on concentrations, distributions and fates of heavy metal wastes in parts of Long Island Sound. Marine Science Inst., Univ. of Connecticut. 132-59.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1973
Country: Australia

Source: 75-M-2

Species: *Crassostrea commercialis*
Number of sites: 18
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, As, Cd, Pb

Mackay, N. J., R. J. Williams, J. L. Kacprzac, M. N. Kazacos, A. J. Collins, and E. H. Auty (1975) Heavy metals in cultivated oysters (*Crassostrea commercialis = Saccostrea cucullata)* from estuaries of New South Wales. Aust. J. Mar. Freshwater Res., 26(-):31-46.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Only concentration mean and ranges reported.

Year: 1973
Country: England

Source: 99 (75-B-3)

Species: *Mytilus edulis, Ostrea edulis, Crassostrea gigas*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Ni, Cu, Zn, Cd, Pb

Boyden, C. R. (1975) Distribution of some trace metals in Poole Harbour, Dorset. Mar. Pollut. Bull., 6(-):180-7.
Poole Harbour is an important south-coast recreational area and supports considerable local industry as well as a small oyster fishery. Unexpectedly high levels of Cd were found in the Harbour. Problems were also encountered in 1972 in the rearing of oyster larvae. This paper reports the results of a study of the levels of Mn, Fe, Ni, Cu, Zn, Cd, and Pb in waters, sediments and biota of Poole Harbour. The samples of biota were digested using concentrated HNO_3 and HCl, and the digestates analyzed using AAS.

Year: 1973
Country: England
Source: 75-J-1

Species: *Mytilus edulis*
Number of sites: 1?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Cd, Pb

Jones, L. H. (1975) The distribution of heavy metals in the Humber estuary and its organisms. Proc., Jt. Symp. Humber Estuary, no. 15. Hull, England, Univ. Dept. of Zoology. 19 pp.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1973
Country: France, Italy, Monaco
Source: 74-F-4

Species: *Mytilus galloprovincialis*
Number of sites: 14
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Mn), (Co), Ni, Cu, Zn, Ag, Cd, Pb

Fowler, S. W., B. Oregioni , J. LaRosa, and W. C. Renfro (1974) Trace element concentrations in mussels of the Ligurian Sea. Activities of the Intl. Lab. Marine Radioactivity, 1974 Rep., Monaco. IAEA-163. IAEA, Vienna, Austria. 119-25.
[INFORMATION IN KIDDER ONLY.] Analysis was done using AAS.

Year: 1972 - 1973
Country: Greenland
Source: 481

Species: *Mytilus edulis*
Number of sites: 1?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Bohn, A. (1975) Arsenic in marine organisms from West Greenland. Mar. Pollut. Bull., 6(6):87-9.
Natural background levels of trace metals in marine organisms from a west Greenland inlet were studied during the summer of 1972 and 1973. The results suggest that in certain marine organisms organoarsenics predominate and are less toxic than inorganic As compounds. Other species were collected and analyzed.

Year: 1973
Country: Australia
Source: 74-A-2

Species: *Crassostrea gigas*
Number of sites: 11
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Pb

Ayling, G. M. (1974) Uptake of cadmium, zinc, copper, lead and chromium in the Pacific oyster, *Crassostrea gigas*, grown in the Tamar river, Tasmania. Water Res., 8(-):729-38.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Sediment data also available.

Year: 1973
Country: Italy

Source: 179 (74-S-4)

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), Ni, Cu, Zn, Pb

Sheppard, C. R. C., and D. J. Bellamy (1974) Pollution of the Mediterranean around Naples. Mar. Pollut. Bull., 5:42-44.
Samples of *Mytilus edulis* were collected from an unpolluted area south of Naples, Italy. The paper compared the metal levels found in this area with those found in the rest of the Bay of Naples. Samples were analyzed using AAS. Other species were also collected and analyzed.

Year: 1973
Country: Mexico

Source: 75-V-2

Species: *Mytilus californianus*
Number of sites: 11
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Vidal, C. E. S., and M. J. A. Ruiz (1975?) Distribución de cobre y zinc en mejillón (*Mytilus californianus*) en la parte noroccidental de la Baja California. Unidad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1973
Country: Norway

Source: 73-L-3

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: As

Lunde, G. (1973) Separation and analysis of organic-bound and inorganic arsenic in marine organisms. J. Sci. Food. Agr., 24(-):1021-7.
[INFORMATION IN KIDDER ONLY.] Analysis done using NAA and XRF.

Year: 1973
Country: Germany

Source: 331

Species: *Mytilus edulis*
Number of sites: 28
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Ca), (Sc), Cr, (Fe), (Co), Ni, Zn, As, Se, (Br), (Rb), (S), (Zr), Ag, Cd, Sn, (Cs), (Ba), (Ta), (Eu), (Tb), (Yb), (Hf), (Au), Hg, (Th)

Karbe, L., C. H. Schnier, and H. O. Siewers (1977) Trace elements in mussels (*Mytilus edulis*) from coastal areas of the North Sea and the Baltic. Multielement analyses using instrumental neutron activation analysis. J. Rad. Chem., 37(-):927-43.
Samples of the mussel *Mytilus edulis* were collected from different sites of estuarine and coastal areas of the North Sea and the Baltic. Regional differences in trace element concentrations were superimposed by typical seasonal variations, with highest concentration levels found in late winter and spring, and lowest in summer and autumn. NIST SRM 1571 (Orchard Leaves) and Bowen's Kale were used as part of the quality assurance protocol. Concentration means and ranges were reported in the paper.

Year: 1973
Country: Puerto Rico
Source: 74-T-3

Species: *Crassostrea rhizophorae*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Ting, R. Y., O. H. Weeler, and E. Robles de Irizarry (1974) The determination of mercury in commercially important aquatic organisms. Puerto Rico Dept. Agriculture. NTIS, Washington, DC. 36 pp.
[INFORMATION IN KIDDER ONLY.] Another species was also collected and analyzed. Data mean and/or range reported on a wet weight basis.

Year: 1973
Country: Scotland
Source: 73-T-2

Species: *Mytilus edulis*
Number of sites: 17
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Topping, G. (1973) Heavy metals in shellfish from Scottish waters. Aquaculture, 1(-):379-84.
[INFORMATION IN KIDDER ONLY.] Results reported on a wet weight basis.

Year: 1973?
Country: South Africa
Source: 73-V-2

Species: *Choromytilus meridionalis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), (Co), Zn, Sb, (Cs)

Van As, D., H. O. Fourie, and C. M. Vleggaar (1973) Accumulation of certain trace elements in marine organisms from the sea around the Cape of Good Hope. Proc., Radioactive Contam. of the Marine Environment. 1972. Seattle, WA. IAEA, Vienna, Austria. 615-24.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS and NAA. Another species also collected and analyzed. Results reported on a wet weight basis. ;

Year: 1973
Country: Taiwan
Source: 73-J-1

Species: *Crassostrea gigas*
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Ni, Cu, Zn, Cd, Hg, Pb

Jeng, S. -. S., and Y. W. Huang (1973) Heavy metal contents in Taiwan's cultured fish. Bull. Inst. Zool. Acad. Sinica, 12(-):79-85.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Results reported on a wet weight basis.

Year: 1973
Country: Wales

Source: 497 (73-I-1)

Species: *Mytilus edulis*
Number of sites: 6
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Zn

Ireland, M. P. (1973) Result of fluvial zinc pollution on the zinc content of littoral and sub-littoral organisms in Cardigan Bay, Wales. Environ. Pollut., 4(-):27-35.
A study was made of the distribution of fluvial Zn in seawater, five littoral animals and one species of seaweed, together with two sub-littoral animals. The distribution of Zn was found to be related to one or several factors, i.e., tidal flow, diet and/or species specificity. Samples were dried and digested in HCl. Zinc levels were determined using AAS. Other species also collected and analyzed.

Year: 1973
Country: United States

Source: 75-R-3b

Species: *Crassostrea gigas, Mytilus edulis*
Number of sites: 6
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Rasmussen, L. F., and D. C. Williams (1975) The occurrence and distribution of mercury in marine organisms in Bellingham Bay. Northwest Sci., 49(-):87-94.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Results reported on a wet weight basis.

Year: 1973 - 1974
Country: Australia

Source: 183

Species: *Mytilus edulis planulatus, Ostrea angasi*
Number of sites: 26
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Ca), (Mn), (Fe), Cu, Zn, Cd, Pb

Harris, J. E., G. J. Fabris, P. J. Statham, and F. Tawfik (1979) Biogeochemistry of selected heavy metals in Western Port, Victoria, Australia, and use of invertebrates as indicators with emphasis on *Mytilus edulis planulatus*. Aust. J. Mar. Freshwater Res., 30(2):159-78.
The relationship of Cd, Cu, Fe, Mn, Pb, and Zn in sediments, seagrasses, and several invertebrates in Western Port were examined. Possible loss of Fe and Pb from tissues of *M. edulis planulatus* during freeze-drying was noted and the concentrations of Cd, Cu, Mn, Zn, and water content were found to be linear functions of mussel length. Composite tissue samples were digested using HNO_3 and $HClO_4$ and the subsequent solutions analyzed for Fe, Mn, and Zn using flame AAS. Chelation-solvent extraction of the solutions and subsequent analysis of the extracts for Cu, Cd, and Pb using AAS. Low levels of Cd, Cu, and Pb were determined using ASV. NIST SRMs 1571 (Orchard Leaves) and 1577 (Bovine Liver) were analyzed as part of the quality assurance protocol.

Year: 1973 - 1974
Country: France, Italy, Monaco
Source: 491 (76-F-1)

Species: *Mytilus galloprovincialis*
Number of sites: 15 (sampled several times during study)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Ag, Cd, Pb

Fowler, S. W., and B. Oregioni (1976) Trace metals in mussels from the NW Mediterranean. Mar. Pollut. Bull., 7(2):26-9.
A coastal survey in the northwestern Mediterranean region was initiated to measure existing levels of selected trace metals in mussels. For most metals, the highest values were found in samples from port cities and areas in the vicinity of river discharge. Marked seasonal variation for many metals was evident. Data comparison indicates that average metal levels in northwestern Mediterranean mussels do not differ markedly from those measured in similar species from different localities throughout the world. The samples were digested using HNO_3 and $HClO_4$, and the dry residue dissolved using HCl. The resulting solutions were analyzed using AAS. NIST SRM 1571 (Orchard Leaves) was analyzed as part of the quality assurance protocol.

Year: 1973 - 1974
Country: Norway
Source: 696

Species: *Ostrea edulis*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Na), (Mg), (K), (Ca), (Mn), (Fe), Cu, Zn, Cd, Pb

Julshamn, K. (1981) Studies on major and minor elements in molluscs in Western Norway - II. Seasonal variations in the contents of 10 elements in oysters (*Ostrea edulis*) from three oyster farms. Fisk. Skr., Ser. Ernaer., 1(5):183-97.
Samples of oysters were collected monthly through one year from three oyster farms in western Norway. Analytical methods in Jushamn (1981).

Year: 1973 - 1975
Country: United States
Source: 637

Species: *Crassostrea virginica*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cd, Hg, Pb

Harvey, E. J., and L. A. Knight (1978) Concentrations of three toxic metals in oysters *Crassostrea virginica* of Biloxi and Pascagoula, Mississippi estuaries. Water, Air, Soil Pollut., 9(-):255-61.
Oysters were shucked and sorted into three size categories. Each group was homogenized and digested using HNO_3, and the digestates extracted using APDC - MIBK. The extracts were dried and the residues dissolved using HNO_3. The solutions were analyzed using AAS. Separate sample digestions were carried out for Hg using a modification of EPA and the Hatch and Ott methods. Data mean and/or range reported on a wet weight basis.

Year: 1973 - 1976
Country: England

Source: 500 (77-W-1)

Species: *Mytilus edulis*
Number of sites: 6
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb

Wharfe, J. R., and W. L. F. Van Den Broek (1977) Heavy metals in macroinvertebrates and fish from the lower Medway estuary, Kent. Mar. Pollut. Bull., 8(-):31-4.
Since the Second World War, expansion of the Medway towns of Rochester, Chatham, and Gillingham and industrial development in this area have increased the threat of pollution in the lower estuary. During ecological studies on the lower Medway estuary, macroinvertebrates and fish were analyzed periodically for five heavy metals, Hg, Zn, Cu, Pb, and Cd using NAA, from April 1973 - January 1976. Data mean and/or range reported on a wet weight basis.

Year: 1974 - 1975
Country: Australia

Source: 919 (76-P-2)

Species: *Mytilus edulis*
Number of sites: 3
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Phillips, D. J. H. (1976) The common mussel *Mytilus edulis* as an indicator of pollution by zinc, cadmium, lead and copper. I. Effects of environmental variables on uptake of metals. Mar. Biol., 38:56-69.
Mussels were collected from Port Phillip Bay and analyzed using procedures employed in previous studies. Results reported on a wet weight basis.

Year: 1974
Country: Australia

Source: 920 (76-P-1)

Species: *Mytilus edulis*
Number of sites: 32
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Phillips, D. J. H. (1976) The common mussel *Mytilus edulis* as an indicator of pollution by zinc, cadmium, lead and copper. II. Relationship of metals in the mussel to those discharged by industry. Mar. Biol., 38:71-80.
Results reported on a wet weight basis.

Year: 1974?
Country: Australia

Source: 74-R-3

Species: *Crassostrea gigas, Crassostrea commercialis*
Number of sites: 20
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd

Ratkowsky, D. A., S. J. Thrower, I. J. Eustace, and J. Olley (1974) A numerical study of the concentration of some heavy metals in Tasmanian oysters. J. Fish. Res. Bd. Can., 31(–):1165-71.
[INFORMATION IN KIDDER ONLY.] Analysis done using AAS.

Year: 1974
Country: England, Wales

Source: 453

Species: *Mytilus edulis, Crassostrea gigas, Ostrea edulis, Crassostrea angulata*
Number of sites: 6?
Analytical methodology?: In previous reports
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Hg, Pb. PCBs. Pesticides.

Murray A. J. (1979) Metals, organochlorine pesticides and PCB residue levels in fish and shellfish landed in England and Wales during 1974. Aquatic environment monitoring response no. 2, MAFF Directorate of Fisheries Research, Lowestoft, UK, 43 pp.
This is the second report of a series recording the results of the fish and shellfish monitoring program. Location of sites listed only as ICES rectangles. Results reported on a wet weight basis.

Year: 1974?
Country: Italy

Source: 679 (75-C-1)

Species: *Mytilus galloprovincialis*
Number of sites: 3
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), (Co), Ni, Cu, (Mo), Cd, Tl

Castagna, A., and F. Sarro (1975) Primi dati sulia di alcuni elementi metallici in Mytilus galloprovincialis, Lam. della costa orientale sicula, svelati con spettrofotometria per assorbimento atomico. Soc. Ital. Biol. Sper., Boll., 51(-):477-83 (Italian).
Analysis done using AAS.

Year: 1974?
Country: Norway

Source: 686

Species: *Mytilus edulis, Ostrea edulis*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Na), (Mg), (K), (Ca), (Mn), (Fe), Cu, Zn, Cd, Pb

Julshamn, K. (1981) Studies on major and minor elements in molluscs in Western Norway - I. Geographical variations in the contents of 10 elements in oyster (*Ostrea edulis*), common mussel (*Mytilus edulis*) and brown seaweed (*Ascophyllum nodosum*) from three oyster farms. Fisk. Skr., Ser. Ernaer., 1(5):161-82.
Specimens of cultured oysters, blue mussels, and brown seaweed were collected monthly from three oysters farms in Norway. The oysters were shucked shortly after collection, dried and dissected by various tissue types. The tissue types were pooled, freeze dried, and homogenized. The tissue samples were digested using HNO_3 and $HClO_4$. Further chelation with sodium diethyl dithiocarbamate and extraction into MIBK was performed prior to Cd and Pb analyses. Elemental analyses were performed using AAS. NIST SRM 1577 (Bovine Liver) and ICES fish flour were analyzed as part of the QA protocol. Seawater and brown seaweed were also collected and analyzed. This study is the first of a series.

Year: 1974
Country: South Africa

Source: 523

Species: *Crassostrea gigas, Crassostrea margaritacea, Choromytilus meridionalis*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Al, Cr, (Mn), (Fe), Ni, Cu, Zn, Cd, Sb, Pb, Bi

Fourie, H. O. (1976) Metals in organisms from Saldanha Bay and Langebaan Lagoon prior to industrialization. South Afr. J. Sci., 72:110-3.
Saldanha Bay is a natural harbor near Cape Town, South Africa, chosen for industrialization. This study was used to establish existing background levels of metals, to monitor future metal pollution using indicator species, and to obtain inter-element relationships and the relationship between accumulation and size and age of specimens. Tissue samples were digested using HNO_3, $HClO_4$ and HCl. The subsequent solutions were analyzed using AAS. The analytical laboratory participated in regular IAEA intercomparison exercises. Results reported on a wet weight basis.

Year: 1974 - 1976
Country: Australia

Source: 76-F-4

Species: *Ostrea angasi, Mytilus edulis planulatus*
Number of sites: 50
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Cd, Pb

Fabris, G. J., F. A. Tawfic, and J. Harris (1976) Concentrations of heavy metals in selected invertebrates from Port Phillip Bay and Westernport. Pub. 164., Section 6. Interim rep. to Environmental Studies Section, Ministry of Conservation, Victoria, Australia. 17 pp.
[INFORMATION IN KIDDER ONLY.] Analyses done using AAS and ASV.

Year: 1975
Country: Australia

Source: 312 (76-T-3)

Species: *Ostrea angasi, Mytilus edulis*
Number of sites: 22
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cd

Talbot, V., R. Magee, and M. Hussain (1976) Cadmium in Port Phillip Bay mussels. Mar. Pollut. Bull., 7(5):84-6.
Port Phillip Bay receives the industrial and domestic effluents from Melbourne and a recent survey revealed an accumulation of a variety of heavy metals on bottom sediments. These studies have now been extended to survey the accumulation in oysters and mussels, and in most areas of the Bay, these bivalves are heavily contaminated with Cd. Oysters accumulate more of this metal than mussels. The samples were digested using HNO_3 and $HClO_4$ and the digestates were analyzed using AAS. [Data set also discussed in: Talbot, V., and R. J. Magee (1977) Cadmium and lead in Port Phillip Bay mussels. Water, 4(2):8-11.]

Year: 1975
Country: Australia

Source: 495 (76-T-4)

Species: *Mytilus edulis*
Number of sites: 22
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Pb

Talbot, V., R. Magee, and M. Hussain (1976) Lead in Port Phillip Bay mussels. Mar. Pollut. Bull., 7(-):234-7.
Lead levels in the indicator mussel *Mytilus edulis*, exceed the WHO food standards in 19 of 22 locations sampled in Port Phillip Bay, Melbourne. While this seriously reflects contamination of the food chain, LD50 experiments on *Mytilus* indicate that the lethal effect of lead on this organism is much less severe than excessive doses of Hg, Cd, Cu, or Zn. The samples were digested using HNO_3 and $HClO_4$ and the digestates were analyzed using AAS. [Data set also discussed in: Talbot, V., and R. J. Magee (1977) Cadmium and lead in Port Phillip Bay mussels. Water, 4(2):8-11.]

Year: 1975
Country: England

Source: (75-D-4)

Species: *Ostrea gigas*
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cd

Darracott, A., and H. Watling (1975) The use of molluscs to monitor cadmium levels in estuaries and coastal marine environments. Trans. Roy. Soc. South Africa, 41(-):325-38.
[INFORMATION IN KIDDER ONLY.]

Year: 1975
Country: England, France, Wales

Source: 454

Species: *Mytilus edulis, Crassostrea gigas, Ostrea edulis, Modiolus modiolus*
Number of sites: 14?
Analytical methodology?: In previous reports
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Hg, Pb. PCBs. Pesticides.

Murray A. J. (1981) Metals, organochlorine pesticides and PCB residue levels in fish and shellfish landed in England and Wales during 1975. Aquatic environment monitoring response no. 5, MAFF Directorate of Fisheries Research, Lowestoft, UK, 40 pp.
This is the third report of a series recording the results of the fish and shellfish monitoring program. Location of sites listed only as ICES rectangles. Results reported on a wet weight basis.

Year: 1975
Country: Ireland

Source: 260 (75-C-2)

Species: *Mytilus edulis*
Number of sites: 26
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), Cu, Zn, Cd, Pb

Crowley M., and C. Murphy (1975) Heavy metals in mussels and in seawater from Irish coastal waters. ICES-CM-1975/E:29, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 10 pp.
Mussels and seawater samples were collected at various locations around the Irish coast. The mussels were shucked and digested with tetramethyl ammonium hydroxide. The digestates were analyzed using GFAAS or AAS. Mercury was analyzed using the Perkin-Elmer Mercury Analysis System. Results reported on a wet weight basis.

Year: 1975
Country: Italy

Source: 417

Species: *Mytilus galloprovincialis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), Cu, Zn, Hg, Pb

Capelli, R., V. Contardi, B. Fassone, and G. Zanicchi (1978) Heavy metals in mussels (*Mytilus galloprovincialis*) from the Gulf of La Spezia and from the promontory of Portofino, Italy. Mar. Chem., 6(-):179-85.
Mussels and water samples were collected from two sites in the Port of La Spezia every month from January to June. Composite tissue samples were digested using HNO_3 and the subsequent solutions analyzed using flame AAS for Mn, Cu, Zn, and Pb, and cold vapor AAS for Hg. NIST SRM 1571 (Orchard Leaves) was analyzed as part of the quality assurance protocol.

Year: 1975
Country: Italy

Source: 340

Species: *Mytilus galloprovincialis*
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), (Co), Ni, Cu, Zn, Cd, Hg, Pb

Majori, L., G. Nedoclan, G. B. Modonutti and F. Daris (1978) Study of the seasonal variations of some trace elements in the tissues of *Mytilus galloprovincialis* taken in the Gulf of Trieste. Rev. Int. Océanogr. Med., 49(-):37-40.
The levels of trace elements were measured every 15 days for two years in four stations located in the Gulf of Trieste. The stations represented different pollution conditions. Only the mean concentrations on a wet weight basis were reported. Results reported on a wet weight basis.

Year: 1975?
Country: Mexico
Source: 75-R-3

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Hg

Reimer, A. A., and R. D. Reimer (1975) Total mercury in some fish and shellfish along the Mexican coast. Bull. Environ. Contam. Toxicol., 14(-):105-11.
[INFORMATION IN KIDDER ONLY.] Other species also collected. Data mean and/or range reported on a dry weight basis.

Year: 1975?
Country: New Zealand
Source: 386 (75-N-2)

Species: *Crassostrea glomerata, Ostrea lutaria, Perna canaliculus, Mytilus edulis, Aulacomya maoriana, Modiolus neozelanicus*
Number of sites: 154
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Fe), Cu, Zn, Cd, Hg, Pb

Nielsen, S. A., and A. Nathan (1975) Heavy metals in New Zealand molluscs (1975) N. Z. J. of Mar. Freshwater Res., 9(4):467-81.
Thirteen species of molluscs from 199 sites in New Zealand were collected and analyzed for trace metals. The specimens were shucked and homogenized, dried and ashed. The ash material was digested in HNO_3 and the digestates analyzed using AAS. Percent recoveries for Fe, Cu, Zn, Cd, and Pb were reported. Hg was analyzed using a cold vapor technique cited in the paper. Other species were collected and analyzed. Results reported on a wet weight basis.

Year: 1975
Country: Norway
Source: 700

Species: *Mytilus edulis*
Number of sites: 11
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Na), (Mg), (K), (Ca), (Mn), (Fe), (Co), Cu, Zn, Cd, Hg, Pb

Julshamn, K. (1981) Studies on major and minor elements in molluscs in Western Norway - VII. The contents of 12 elements, including copper, zinc, cadmium and lead, in common mussel (*Mytilus edulis*) and brown seaweed, (*Ascophyllum nodosum*) relative to the distance from the industrial sites in Sørfjorden, inner Hardangerfjord. Fisk. Skr., Ser. Ernaer., 1(5):267-87.
Samples of seawater, brown seaweed, and blue mussels were collected from sites in the Sørfjorden. Industrial sites at the head of the fjord discharge heavy metals to the water. Most element concentrations in the water decreased rapidly within the first 15 km. Levels of Pb and Hg in mussels correlated to distance from the point of discharge. Blue mussels were collected, washed, and freeze dried. Analyses were done using AAS.

Year: 1975?
Country: South Africa

Source: 75-V-1

Species: *Choromytilus meridionalis*
Number of sites: Average of 6 sites
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), (Co), Zn, Sb, (Cs)

Van As, D., H. O. Fourie, and C. M. Vleggaar (1975) Trace element concentrations in marine organisms from the Cape West Coast. S. Afr. J. Sci., 71:151-4.
[INFORMATION IN KIDDER ONLY.] Analyses done using AAS and INAAS. Results reported on a wet weight basis.

Year: 1975?
Country: South Africa

Source: 438 (76-W-1)

Species: *Crassostrea margaritacea, Crassostrea cucullata, Ostrea algoensis*
Number of sites: Average of 6 sites
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Ni, Cu, Zn, Ag, Cd

Watling, H. R., and R. J. Watling (1976) Trace metals in oysters from Knysna estuary. Mar. Pollut. Bull., 7(3):45-8.
A preliminary survey of seven trace metals in three species of oyster from Knysna estuary, South Africa, was carried out. The results which were obtained indicate that this area is as yet unpolluted and provides baseline levels against which future trace metal pollution can be measured. Two species of oyster are being grown at a number of sites as part of a long-term programme to monitor trace metal levels in the estuary. The oysters were purged, shucked, and dried. The dry tissue was digested using HNO_3 and $HClO_4$ and the subsequent solution analyzed using AAS.

Year: 1975?
Country: UK

Source: 75-G-3

Species: *Mytilus edulis, Ostrea edulis*
Number of sites: 2?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn

George, S. G., and T. L. Coombs (1975) A comparison of trace-metal and metalloenzyme profiles in different molluscs and during development of the oyster. Proc., 7th Symp. Marine Biology. H. Barnes (ed.). 433-49.
[INFORMATION IN KIDDER ONLY.] Analyses done using AAS. Results reported on a wet weight basis.

Year: 1975
Country: United States

Source: 482 (75-G-1)

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Ag, Cd, Pb

Greig, R. A., B. A. Nelson, and D. A. Nelson (1975) Trace metal content in the American oyster. Mar. Pollut. Bull., 6(5):72-3.
This study was designed to measure the transfer of metals from adults to eggs of the American oyster. Two groups of oysters containing significantly different levels of Cu and Cd were induced to spawn, the eggs were collected and trace metal contents measured. The eggs from both groups of oysters contained the same amount of Cu, while the Cd levels were below

detectable limits on both groups of eggs. The concentrations of the other metals were similar for both groups of adults and eggs, thus no conclusion could be made about the transfer of these three metals from adults to eggs of oysters. The dried oyster tissues were digested using HNO_3 and the subsequent digestates analyzed using AAS.

Year: **1975?**
Country: **United States**
Source: **75-R-2**

Species: *Crassostrea virginica*
Number of sites: ?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Ruddell, C. L., and D. W. Rains (1975) The relationship between zinc, copper and the basophils of two *Crassostreid* oysters, *C. gigas* and *C. virginica*. Comp. Biochem. Physiol., 51A:585-91. [INFORMATION IN KIDDER ONLY.] Analysis done using AAS. Data mean and/or range reported on a dry weight basis for some sites.

Year: **1975 - 1977**
Country: **England**
Source: **677**

Species: *Ostrea edulis* and *Mytilus edulis*
Number of sites: NA
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, As, Cd

Klumpp, D. W., and P. J. Peterson (1979) Arsenic and other trace elements in the waters and organisms of an estuary in SW England. Environ. Pollut., 19(1):11-20.
Water and organisms were collected in the Carnon River and the upper reaches of Restronguet Creek. Arsenite was found to be the main form of As in the Carnon River, and this species was converted to arsenate in the lower estuary. There was no evidence of biomagnification of As on an entire organism basis. Oysters and mussels were collected between November 1975 and September 1977, washed in sea water and frozen. Samples of dried tissue were digested using HNO_3 and $HClO_4$. The resulting digestates were taken to volume using HCl and analyzed using AAS. NIST SRM 1571 (Orchard Leaves) and Bowen's Kale were analyzed as part of the study. Data mean and/or range reported on a dry weight basis.

Year: **1976**
Country: **Canada**
Source: **493 (76-B-1)**

Species: *Mytilus edulis*
Number of sites: 27
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Hg

Bourget, E., and D. Cossa (1976) Mercury content of mussels from the St. Lawrence Estuary and northwestern Gulf of St. Lawrence, Canada. Mar. Pollut. Bull., 7(12):237-9.
A first survey of the Hg content of intertidal mussels in the St. Lawrence Estuary and part of the Gulf of St. Lawrence shows means values ranging from 0.160 to 0.629 µg/g dry weight. The results indicate a decreasing gradient in Hg levels from the mouth of the Saguenay Fjord seaward. Mercury content was determined using flameless AAS.

Year: 1976
Country: Denmark, Finland, Norway, Sweden
Source: 169

Species: *Mytilus edulis*
Number of sites: 54
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Zn, Cd

Phillips, D. J. H. (1977) The common mussel *Mytilus edulis* as an indicator of trace metals in Scandinavian waters. I. Zinc and cadmium. Mar. Biol., 43(4):283-91.
Concentrations of Zn and Cd in whole soft parts of mussels collected from 54 locations in Scandinavian waters were determined. Local variations in concentrations of the two metals found in samples taken close to industrial sources of Zn and Cd confirmed the ability of the mussel to act as an accurate indicator of pollution by these metals over the entire range of salinities in which this species can exist. Composites of 20 mussels were digested using HCl and the digestates analyzed using AAS.

Year: 1976
Country: England, Wales
Source: 455

Species: *Mytilus edulis, Crassostrea gigas, Ostrea edulis*
Number of sites: 11?
Analytical methodology?: In previous reports
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Hg, Pb. PCBs. Pesticides.

Murray A. J., and J. E. Portmann (1984) Metals, organochlorine pesticides and PCB residues in fish and shellfish in England and Walesin 1976 and trends since 1970. Aquatic environment monitoring response no. 10, MAFF Directorate of Fisheries Research, Lowestoft, UK, 79 pp.
This is the fourth report of a series recording the results of the fish and shellfish monitoring program. Location of sites listed only as ICES rectangles. Results reported on a wet weight basis.

Year: 1976
Country: India
Source: 477

Species: *Mytilus viridis*
Number of sites: 31
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), (Co), Ni, Cu, Zn, Pb

Bhosle, N. B., and S. G. P. Matondkar (1978) Variation in trace metals in two populations of green mussel *Mytilus viridis* L. from Goa. Mahasagar, 11(3-4):191-4.
Seven trace metals were analyzed from the tissues of the green mussel, *Mytilus viridis*. The specimens were from the natural beds at Velsao and from the ropes suspended at Dona Paula for mussel culture. In general, the rope cultured animals showed a higher concentration of metals than those from the natural beds. These changes seem to be related to their continued submergence in seawater. The samples were digested using HNO_3, $HClO_4$, and HCl and the subsequent solutions analyzed using AAS.

Year: 1976?
Country: Monaco
Source: 76-F-2

Species: *Mytilus galloprovincialis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Se

Fowler, S. W., and G. Benayoun (1976) Accumulation and distribution of selenium in mussel and shrimp tissues. Bull. Environ. Contam. Toxicol., 16(-):339-46.
[INFORMATION IN KIDDER ONLY.] Analysis done using NAA.

Year: 1976?
Country: South Africa
Source: 489 (76-W-2)

Species: *Choromytilus meridionalis*, *Crassostrea gigas*
Number of sites: 3?
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Ag, Cd, Pb

Watling, H. R., and R. J. Watling (1976) Trace metals in *Choromytilus meridionalis*. Mar. Pollut. Bull., 7(5):91-4.
Concentrations of metals in mature females of the mussel *Choromytilus meridionalis* were approximately twice those in males and some other trace elements also differ according to sex. If this species is to be used as an indicator of trace metal pollution, comparative data should relate to individuals of similar size and care must be taken to determine whether differences in trace metal content are the result of seasonal variations or reflect abnormal metal uptake. Specimens collected in Saldanha Bay were dried and the dry tissues digested using HNO_3 and $HClO_4$. The digestates were analyzed using AAS. Sediment was also collected and analyzed as part of this study.

Year: 1976 - 1977
Country: Taiwan
Source: 697

Species: *Crassostrea gigas*
Number of sites: 7
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Na), (Mg), (K), (Ca), (Fe), Ni, Cu, Zn, Cd, Hg, Pb

Hsu, S-Y., G-S. Wang, and S-S. Jeng (1979) The occurrence and seasonal variations of sodium potassium calcium magnesium and heavy metals in Taiwan's oysters and clams. Bull. Inst. Zool. Acad. Sin. (Taipei), 18(1):11-20.
Shucked oysters and marketed clams were collected along the coast of Taiwan to study the seasonal variation of various elements. Seasonal Na and glycogen changes were found to be almost identical, an indication of possible connection between Na and spawning. Tissue samples were digested using H_2SO_4 and HNO_3. Sodium and K were measured using flame photometry; Ca, Mg, Fe and Zn using AAS; Cu, Pb and Cd using AAS after extraction with APDC-MIBK; and Hg using flameless AAS. Results reported on a wet weight basis.

Year: 1976 - 1978
Country: United States

Source: EPA

Species: *Crassostrea virginica, Mytilus edulis, Mytilus galloprovincialis*
Number of sites: 92
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Ni, Cu, Zn, Cd, Hg, Pb. PCBs. DDTs. PAHs.

Goldberg, E. D., V. T. Bowen, J. W. Farrington, G. Harvey, J. H. Martin, P. L. Parker, R. W. Risebrough, W. Robertson, E. Schneider, and E. Gamble (1978) The Mussel Watch. Environ. Conserv., 5(2):101-25.

Farrington, J. W., et al. (1983) U.S. Mussel Watch 1976-1978: an overview of the trace metal, DDe, PCB, hydrocarbon and artificial radionuclide data. Environ. Sci. Technol., 17:490-6.

The Mussel Watch Program began in 1976 as surveillance of U.S. coastal regions for their pollutant contents utilizing species of mussels and oysters as surveillance organisms. Analyses were performed by five participating laboratories. The procedures for the monitoring programme were formulated by a guidance committee composed of scientists involved in the analytical work. A single scientist operating from a mobile laboratory was employed for the collection of specimens nationwide. [Station locations in: Palmieri, J., H. Livingston, and J. W. Farrington (1984) U.S. "Mussel Watch" Program: transuranic element data from Woods Hole oceanographic Institution, 1976-1983. Tech. Rep. WHOI-84-24. CRC-84-5. WHOI, Woods Hole, MA. 73 pp.]

Year: 1976 - 1980
Country: United States

Source: 619

Species: *Crassostrea virginica*
Number of sites: ?
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, Cu, Zn, As, Cd, Hg, Pb

Eisenberg, M., and J. J. Topping (1984) Trace metal residues in shellfish from Maryland waters, 1976 - 1980. J. Environ. Sci. Health, B19(7):649-71.

Levels of heavy metals were monitored in specimens of the American oysters and other species collected in the Chesapeake Bay to provide baseline values. During the study, 985 samples of oysters were harvested. The oysters were shucked, homogenized, and digested using HNO_3. Separate digestions were made for As and Hg determinations. Copper, Zn, Cr, Cd, and Pb were determined using AAS. Arsenic was determined colorimetrically and Hg was determined using CVAAS. Data mean and/or range reported on a wet weight basis.

Year: 1977
Country: Australia

Source: 155

Species: *Mytilus edulis, Ostrea angasi*
Number of sites: 30
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), (Fe), Cu, Zn, Cd, Pb

Talbot, V., and A. Chegwidden (1982) Cadmium and other heavy metal concentrations in selected biota from Cockburn Sound, Western Australia. Aust. J. Mar. Freshwater Res., 33(5):779-88.
Heavy metals were determined in mussels, oysters, and other species collected in Cockburn Sound, Western Australia. The highest concentrations of Cd, Cr, and Pb were found in mussels, and of Cd and Zn in oysters collected in the vicinity of industrial discharge points. Tissues were digested using HNO_3 and the subsequent solutions analyzed using AAS. NIST SRMs 1971 (Orchard Leaves) and 1577 (Bovine Liver), and secondary standards of the EPA (Victoria) and Murdoch University (Western Australia) were analyzed as part of the QA protocol. Other species were also collected and analyzed. Results reported on a wet weight basis.

Year: 1977
Country: Australia

Source: 19

Species: *Mytilus edulis*
Number of sites: 18
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd, Pb

Smith, J. D., E. C. V. Butler, G. W. Little, P. J. Milne, B. R. Grant, and N. Millis (1981) Distribution and significance of copper, lead, zinc and cadmium in the Corio Bay ecosystem. Aust. J. Mar. Freshwater Res., 32(2): 151-64.
Levels of Cu, Pb, Zn and Cd in sediments, waters, and mussels from Corio Bay were measured on two occasions in 1977. Corio Bay has received a major input of Cd. The observed levels of heavy metals were compared with threshold levels reported in the literature and cause significant interference with growth of phytoplankton and nutrient cycling by bacterial processes. Composite mussel samples were digested with HNO_3 and $HClO_4$. The digestate was analyzed for Zn using flame AAS. The digestates were also extracted with APDC and diisobutylketone and the extracts were analyzed for Pb, Cu, and Cd using AAS. Composite tissue control samples were analyzed as part of the study.

Year: 1977
Country: Denmark, Sweden

Source: 850

Species: *Mytilus edulis*
Number of sites: 19
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Zn, Cd, Pb

Phillips, D. J. H. (1979) Trace metals in the common mussel, *Mytilus edulis* (L.), and in the alga *Fucu vesiculosus* (L.) from the region of the Sound (Oresund). Environ. Pollut., 18(-):31-43.
Specimens of blue mussel and the alga *Fucus* were collected in the Oresund Sound and analyzed. Pollution profiles for each metal were similar in any one of the species studied but the profiles for metals in the mussels were distinct for those in the alga. The alga probably responds only to metals present in solution where the metal level in the mussels depends upon the levels found in plankton.

Year: 1977
Country: Denmark, Finland, Norway, Sweden
Source: 167 (77-P-2)

Species: *Mytilus edulis*
Number of sites: 54
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Pb

Phillips, D. J. H. (1978) The common mussel *Mytilus edulis* as an indicator of trace metals in Scandinavian waters. II. Lead, iron and manganese. Mar. Biol., 46(2):147-56.
Concentrations of Pb, Fe, and Mn in whole soft parts of mussels collected from 54 locations in Scandinavian waters were determined. The indicator ability of the mussel for these metals in tested by considering local variations in concentrations of the three metals in relation to known industrial sites. A general agreement with previous published data was reached; the indicator capability of the mussel for Pb and Fe was supported over the entire prevalent salinity range in the study area, whereas that for Mn appeared dubious, at least in low salinity regions. Composite mussel tissue samples were digested with HCl and the digestate was analyzed using flame AAS.

Year: 1977
Country: England, Wales
Source: 163

Species: *Ostrea edulis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn

George, S. G., B. J. S. Pirie, A. R. Cheyne, T. L. Coombs, and P. T. Grant (1978) Detoxification of metals by marine bivalves: an intrastructural study of the compartmentation of copper and zinc in oyster *Ostrea edulis*. Mar. Biol., 45(2):147-56.
An investigation of the mechanisms of detoxication of Cu and Zn by the oyster *Ostrea edulis* was carried out using naturally occurring "green-sick" (contaminated by Cu) and unpolluted oysters. Electron microprobe x-ray analysis of tissues in the electron microscope gave direct evidence for the structural compartmentation of Cu and Zn in separate, specific, granular amoebocytes. The metals are immobilized in membrane-limited vesicles as different chemical compounds, Cu being associated with S and Zn with phosphorus. The oysters were shucked, dried, and digested using HCl. The digestates were analyzed using AAS. Results reported on a wet weight basis.

Year: 1977
Country: Lebanon
Source: 305

Species: *Brachydontes variabilis*
Number of sites: 8
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Ni, Cu, Cd, Pb

Shiber, J. G., and T. A. Shatila (1978) Lead, cadmium, copper, nickel and iron in limpets, mussels and snails from the coast of Ras Beirut, Lebanon. Mar. Environ. Res., 1(-):125-34.
Samples of *Patella coerulea*, *Brachydontes variabilis*, *Monodonta turbinata* and surface seawater were collected at eight locations along the coast of Ras, Beirut, Lebanon, and analyzed for Pb, Cd, Cu, Ni, and Fe. With the exception of Cd, the metal levels found in the three mollusks appear to be high in relation to levels reported by investigators from other coastal areas. The average values for Pb, Cd ,and Ni within these animals were quite similar. Analysis was done using flame AAS. With the exception of Cd, metal levels found in the three species of molluscs were high in relation to levels reported by other investigators.

Year: 1977
Country: Scotland
Source: 391

Species: *Mytilus edulis*
Number of sites: 14
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb

Davies, I. M., and J. M. Pirie (1978) Trace metals in mussels from the Scottish coast. ICES-CM-1978/E:33, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 7 pp.

This is an interim report of an extensive survey of heavy metal content of intertidal mussels from Scottish waters. Mussels were allowed to depurate, shucked, and homogenized. The tissues were digested with HNO_3 and the digestates analyzed using AAS. Mercury was analyzed using a method described in the paper.

Year: 1977
Country: United States
Source: 213

Species: *Crassostrea virginica*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Cd

Carriker, M. R., R. E. Palmer, L. V. Sick, and C. C. Johnson (1980) Interaction of mineral elements in sea water and shell of oysters [(*Crassostrea virginica* (Gmelin)] cultured in controlled and natural systems. J. Exp. Mar. Biol. Ecol., 46:279-96.

The interaction of various elements in seawater with soft tissues, prismatic calcite of the right valve, and floated calcite of right and left valves grown in natural and controlled systems was studied. Tissues were digested using low-temperature oxygen plasma ashing and the ashes dissolved using HNO_3. The digestates were analyzed using GFAAS. Results reported on a wet weight basis.

Year: 1977 - 1978
Country: England
Source: 883

Species: *Mytilus edulis*
Number of sites:
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Zn

Lobel, P. B., and D. A. Wright (1983) Frequency distribution of zinc concentrations in the common mussel *Mytilus edulis* (L.). Estuaries, 6(-):154-9.

The frequency distribution of Zn concentrations in mussels from the moderately polluted Tyne estuary showed marked positive skewness. A peak was reached between 3 to 4 µmoles per dry gram of whole soft tissue. Twenty-five collections were made during 1977 and 1978. The mussels were allowed to depurate, shucked, and dried. The tissues wet digested using HNO_3 and $HClO_4$ and the digestates analyzed using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1977 - 1978
Country: England, Wales

Source: 266

Species: *Mytilus edulis*
Number of sites: 78
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb. (PCBs), (DDTs), (Pesticides), (HC), (PAHs)

Murray A. J., and R. J. Law (1980) Results of a mussel watch programme in England and Wales. 1977 and 1978. ICES-CM-1980/E:15, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 14 pp.
During 1977 to 1978, mussel surveys of England and Wales were done to determine the level of trace metals, organochlorine pesticides, PCBs, and petroleum hydrocarbons in specimens collected along the coast. Samples were digested using HNO_3 and H_2O_2. The digestates were analyzed for Cu and Zn using flame AAS. Lead and Cd were determined using flame AAS after complexation with ammonium tetramethylene dithiocarbamate and extraction of the complex into 4-methyl-2-pentanone. Mercury was determined using an automated flameless technique. Samples collected from areas with significant anthropogenic inputs had the highest contaminant concentrations. The 1977 data were reported on a wet weight basis.

Year: 1977 - 1978
Country: India

Source: 524

Species: *Perna viridis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Pb

Lakshmanan, P. T., and P. N. K. Nambisan (1983) Seasonal variations in trace metal content in bivalve molluscs, *Villorita cyprinoides* var. *cochinensis* (Hanley), *Meretrix casta* (Chemnitz) & *Perna viridis* (Linnaeus). Indian J. Mar. Sci., 12:100-3.
Molluscs were collected monthly to study seasonal variations. The specimens were depurated and tissues composited, dried, and digested in concentrated HNO_3 and H_2SO_4. The material used for the determination of Pb was digested according to AOAC procedures. Trace metal content of the digestates was estimated using AAS. Species of the clams *Villorita cyprinoides* and *Meretrix casta* were also collected.

Year: 1977 - 1984
Country: England, Isle of Man, Wales

Source: 308

Species: *Mytilus edulis, Modiolus modiolus*
Number of sites: 39
Analytical methodology?: In cited paper.
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb. (PCBs), (DDTs), (Pesticides).

Franklin, A. (1987) The concentration of metals, organochlorine pesticide and PCB residues in marine fish and shellfish: results from MAFF fish and shellfish monitoring programmes, 1977 - 1984. Aquatic environment monitoring response no. 16, MAFF Directorate of Fisheries Research, Lowestoft, UK, 38 pp.
This report is part of the monitoring effort by MAFF and contains the results of the analyses of specimens collected from 1977 to 1984.

Year: 1977 - 1978
Country: United States
Source: 114

Species: *Mytilus californianus*
Number of sites: 2 (several times each)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Co), (Mn), Ni, Cu, Zn, Cd, Hg, Pb

Gordon, M., G. A. Knauer, and J. H. Martin (1980) *Mytilus californianus* as a bioindicator of trace metal pollution: variability and statistical considerations. Mar. Pollut. Bull., 11(7):195-98.

Trace metal variability was evaluated in two populations of *Mytilus californianus* through the analysis of individual specimens. Mussels were obtained from two sites in the Southern California Bight in January 1977 and April 1978. The gonad was removed and the remainder of the organism was lyophilized. Digestions of the freeze dried tissues was performed using HNO_3 and H_2O_2 and the digestates were analyzed for Al, Cd, Cr, Cu, Fe, Ni, Pb, and Zn using graphite furnace AAS. NIST SRM 1571 (Orchard Leaves) and SRM 1577 (Bovine Liver) were analyzed as part of the study.

Year: 1977 - 1979
Country: England
Source: 124

Species: *Mytilus edulis*
Number of sites: 1 (monthly)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Co), (Mn), Ni, Cu, Zn, Cd, Hg, Pb

Boalch, R., S. Chan, and D. Taylor (1981) Seasonal variation in the trace metal content of *Mytilus edulis*. Mar. Pollut. Bull., 12(8):276-80.

The possible seasonal variation in the trace metal content of *Mytilus edulis* has been studied by analyzing Cd, Co, Cu, Pb, Mn, Hg, Ni, and Zn in 560 individuals collected from the same mussel bed over a period of two years. A clearly discernible effect of size on metal concentration was detected. However, no seasonal trends could be seen in the data. Mercury determinations were carried out on a $KMnO_4$ - H_2SO_4 digest of the tissue using cold vapor AAS. The other elements were determined using flame AAS after concentrated HNO_3 digestion. Analytical details are available from the authors. Hg levels were reported as wet weight.

Year: 1978
Country: England
Source: 108

Species: *Mytilus edulis*
Number of sites: 2
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn

Simpson, R. D. (1979) Uptake and loss of zinc and lead by mussels (Mytilus edulis) and relationships with body weight and reproductive cycle. Mar. Pollut. Bull., 10(3):74-8.

The uptake of Cu and Zn by mussels was studied under natural conditions in northeast England. Mussels from contaminated areas were transferred to clean areas and vice versa. Indications of uptake and loss were affected by changing body weights and reproductive cycle.

Year: 1978
Country: Hong Kong

Source: 143

Species: *Saccostrea glomerata*, *Septifer binocularis*
Number of sites: 20
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Cu, Zn

Phillips, D. J. H., and W. W. S. Yim (1981) A comparative evaluation of oysters, mussels and sediments as indicators of trace metals in Hong Kong waters. Mar. Ecol., 6(-):285-93.
Oysters (*Saccostrea glomerata*) taken from 20 locations revealed considerable contamination of the heavily urbanized Victoria Harbour area by Cu and Zn. Data for Cu and Zn in sediments, based on samples from 210 sites, confirmed this finding. In addition, mussels (*Septifer binocularis*) were collected twice from 23 locations.

Year: 1978
Country: Hong Kong

Source: 843

Species: *Crassostrea gigas*
Number of sites: 8?
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, As, Cd, Hg, Pb

Phillips, D. J. H., C. T. Ho, and L. H. Ng (1982) Trace elements in the Pacific oyster in Hong Kong. Arch. Environ. Contam. Toxicol., 11(-):533-7.
Oysters obtained from local markets and a local culture area were analyzed. The samples were shucked, rinsed and frozen. Upon thawing, the samples were homogenized and digested using HNO_3 and H_2SO_4. The subsequent digestates were analyzed for Cu, Zn, Cd, and Pb using GFAAS, for As using the Gutzeit method, and for Hg using CVAAS. NIST RM 50 (Tuna Homogenate) and the IAEA series of intercalibration materials. Results reported on a wet weight basis.

Year: 1978
Country: Hong Kong

Source: 186

Species: *Saccostrea glomerata*
Number of sites: 54
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Cd

Phillips, D. J. H. (1979) The rock oyster *Saccostrea glomerata* as an indicator of trace metals in Hong Kong. Mar. Biol., 53(4):353-360.
Preliminary studies were undertaken to test the indicator ability of the rock oyster, *Saccostrea glomerata* for monitoring the trace metals Cd, Cu, Fe, and Zn in a sub-tropical and tropical environment. A survey of these trace metals in rock oysters from 54 sites in Hong Kong waters revealed elevated levels of metals in several areas. Profiles of metal abundance in *S. glomerata* agreed substantially with the distribution of contamination found in studies of the Pacific oyster *Crassostrea gigas* and of sediments. Tissue samples were digested in concentrated HNO_3, H_2SO_4, and $HClO_4$ and subsequent analysis of the resulting solutions using flame AAS.

Year: 1978
Country: Iceland

Source: 194

Species: *Mytilus edulis*
Number of sites: 48
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb

Olafsson, J. (1986) Trace metals in mussels (*Mytilus edulis*) from southwest Iceland. Mar. Biol., 90(2):223-9.
The purpose of this study was to establish baseline conditions to evaluate anthropogenic influences. Sampling of mussels was done according to ICES guidelines. The frozen specimens were thawed and dissected. The tissues were digested using H_2SO_4, HNO_3, and $KMnO_4$ for Hg analysis; HNO_3 for Cd, Cu. and Zn analyses; and HNO_3 as a separate digestion for Pb. Zinc was determined using AAS and the other elements using GFAAS. The analytical laboratory that performed the analysis participated in an ICES intercalibration exercises. Data mean and/or range reported on a dry weight basis.

Year: 1978
Country: Northern Ireland

Source: 721

Species: *Mytilus edulis*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), Cu, Zn, Cd, Pb

Manga, N. (1980) Trace metals in the common mussel *Mytilus edulis* from Belfast Lough. Ir. Nat. J., 20(4):160-3.
Mussels were collected from the Belfast Lough, Ireland. The specimens were placed in clean seawater to allow depuration to occur. The mussels were then shucked, and the tissues pooled and oven-dried. The dried tissues were digested in concentrated HNO_3 and the resulting solutions analyzed using AAS. Only concentration ranges and means listed in the cited paper. Data mean and/or range reported on a dry weight basis.

Year: 1978
Country: United States

Source: 869

Species: *Crassostrea virginica*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Be), (Ti), (V), (Fe), Co, Cu, Zn, As, Se, (Sr), Cd, Sb, Hg, Pb

Lytle, T. F., and J. S. Lytle (1982) Heavy metals in oysters and clams of St. Louis Bay, Mississippi. Bull. Environ. Contam. Toxicol., 29:50-7.
St. Louis Bay is a shallow embayment in the Mississippi Sound with very little anthropogenic input of pollutants. In 1979, a large TiO_2 refinery was built on the north shore and there was concern about possible contamination of the area. This study was designed to determine baseline values for the area. Wet oyster tissue samples were digested using HNO_3 and H_2SO_4, with subsequent addition of H_2O_2. The digestates were analyzed using AAS. For As, Sb, Se, and Hg, different methodology was used. Results reported on a wet weight basis.

Year: 1978
Country: United States
Source: 145

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Ag, Cd

Phelps, H. L., D. A. Wright, and J. A. Mihursky (1985) Factors affecting trace metal accumulation by estuarine oysters *Crassostrea virginica*. Mar. Ecol., 22(2):187-98.
Oysters were collected from the Chesapeake Bay at stations that represent high and low salinity regimes and potentially different trace metal inputs. Wet weight trace metal concentrations were found to be largely negatively correlated with body weight and salinity. Oysters were scrubbed, shucked, and digested with HNO_3. The digestates were analyzed using GFAAS. Data for Cd and Ag and for other collection years are available in other citations. Results reported on a wet weight basis.

Year: 1978 - 1981
Country: England
Source: 181

Species: *Mytilus edulis*
Number of sites: 3
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: As

Langston, W. J. (1984) Availability of arsenic to estuarine and marine organisms: a field and laboratory evaluation. Mar. Biol., 80(2):143-54.
The paper reports the results of surveys and experiments conducted to study the availability of As to estuarine organisms. Water, sediment, and selected organisms were collected from Restronguet Creek, the Tamar, and the Torridge estuaries. Analysis of As was done using hydride generation AAS. Restronguet Creek is contaminated due to mining activities. *Mytilus edulis* did not respond as fast as other mollusk species studied.

Year: 1978 - 1979
Country: Isle of Man
Source: 334

Species: *Mytilus edulis*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Southgate, T., D. J. Slinn, and J. F. Eastham (1983) Mine-derived metal pollution in the Isle of Man. Mar. Pollut. Bull., 14(4):137-40.
The sediments of rivers draining areas of past mining activity in the Isle of Man contained greatly enhanced levels of Zn, Pb and, to a lesser extent, Cu and Cd. Individual variation of metal levels was high in all species of bivalves examined; a demonstrated correlation of dry weight:metal content was demonstrated in many cases, but other factors may also contribute to such variations. Dry tissues were digested using HNO_3 and the digestates analyzed using AAS.

Year: 1978 - 1983
Country: United States

Source: 536

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Na), (Mg), (Al), (Cl), (K), (Ca), (Sc), (V), Cr, (Mn), (Fe), (Co), Cu, Zn, (Br), (Rb), Ag, Cd, (Te), (La), (Au), (U)

Gavrilas, M., and F. J. Munno (1984) Elemental composition of Chesapeake Bay oyster *Crassostrea virginica* in the vicinity of Calvert Cliffs nuclear power plant. In: Proc., 5th Int. Conf. Nucl. Methods Environ. Energy Res. Vogt, J. R., (ed.), NTIS, Springfield, VA, 348-56.
The stable element composition of oysters collected in the vicinity of the Calvert Cliffs Nuclear Power Plant, Chesapeake bay, between 1978 and 1983 was determined. After collection the oysters were dried and ashed, the ashed tissue analyzed using INAA. Data mean and/or range reported on a wet weight basis.

Year: 1978 - 1984
Country: Scotland

Source: 2

Species: *Modiolus modiolus*
Number of sites: 6-10
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (V), Cr, Ni, Cu, Zn, Cd, Pb

Gibson, M. J., W. C. Grogan, and J. A. McDougall (1985) Biological monitoring of trace metals using local populations of marine bivalve molluscs. In: Heavy Metals in the Environment (International Conf.). Vol. I. Athens, Greece, September, 1985. CEP Consultants Ltd., Edinburgh, UK. 712-4.
The biological monitoring capability of two marine bivalve molluscs, *Modiolus modiolus* and *Chlamys opercularis* was investigated over a 6-year (1978 - 1984) period at Sullom Voe, Shetland, U.K. The animals were used to measure the biological uptake of trace elements in locally discharged metal-enriched oily-water effluent. Aliquots of homogenized *Modiolus* soft tissue and individual *Chlamys* were digested using concentrated HNO_3 and analyzed for Cd, Cr, Cu, Ni, Pb, V and Zn using DC argon plasma emission spectrometry. Standard reference materials were analyzed as part of the study. Data mean and/or range reported on a dry weight basis.

Year: 1979
Country: Australia

Source: 272

Species: *Pinctada margaritifera, Modiolus auriculatus*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Co, Ni, Cu, Zn, Ag, Cd, Pb

Klumpp, D. W., and C. Burdon-Jones (1982) Investigation of the potential bivalve mollusca as indicators of heavy metal levels in tropical marine waters. Aust. J. Mar. Freshwater Res., 33(2):285-300.
The relationships between concentrations of heavy metals Pb, Cd, Cu, Zn, Co, Ni and Ag in nine bivalve species (*Arca ventricosa, Chama isotoma, Lithophaga teres, Pinctada margaritifera, Pycnodonte hyotis, Spondylus ducalis, Modiolus auriculatus, Trichomya hirsuta, Ustularca renuta*) collected at Townsville, Australia, and their environment were studied. The variation in heavy metal accumulation in these field samples and the effects on metal levels and condition of the organisms after relocating for 2 months four of the species were also studied. Tissues

were digested using HNO_3 and $HClO_4$ and the digestates were analyzed using AAS. NIST SRM 1577 (Bovine Liver) was used as part of the quality assurance protocol.

Year: **1979**
Country: **Australia**

Source: **206**

Species: *Mytilus edulis*
Number of sites: 20
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Pb

Talbot, V. (1987) Relationship between lead concentrations in seawater and in the mussel *Mytilus edulis*: A water-quality criterion. Mar. Biol., 94(4):557-60.
Regression analysis on data collected from Port Phillip Bay and Western Port, Australia, in 1979 showed that there is a significant equilibrium relationship between total recoverable Pb in seawater and its concentration in the *Mytilus edulis*.

Year: **1979**
Country: **Canada**

Source: **274**

Species: *Mytilus edulis*
Number of sites: 8
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Pb

Popham, J. D., and J. M. D'Auria (1983) Statistical approach for deciding if mussels (*Mytilus edulis*) have been collected from a water body polluted with trace metals. Environ. Sci. Technol., 17(10):576-82.
The paper describes a statistical approach to decide whether specimens of *Mytilus edulis* can be used to determine the level of contamination of the water in which they are found. Principal component analyses was applied to the correlation matrix of variables measured in specimens collected monthly over a 12 month period from an unpolluted estuary in British Columbia. Elemental analysis was done using x-ray energy spectroscopy.

Year: **1979**
Country: **Germany**

Source: **744**

Species: *Mytilus edulis*
Number of sites: 32
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Na), (K), As, Se, (Br), (Ca), (Sc), Cr, (Fe), (Co), Ni, Zn, (Rb), Ag, Cd, Sn, Sb, (Cs), (La), (Ce), (Eu), (Tb), (Hf), (Ta), (Au), Hg, (U), PCBs

Müller, H., R. Schneider, and C. Schnier (1983) Trace metal and PCB content of mussels (*Mytilus edulis*) from the southwestern Baltic Sea. Int. Rev. Gesamten Hydrobiol., 68(5):633-47.
The concentrations of PCBs and 28 elements were determined in mussels collected in the southwestern Baltic Sea. The discharge from a sewage plant is responsible for high residues at stations in the outlet of the Kiel Fjord. Increased levels of heavy metals in the outer Flensburg Fjord and the vicinity of the Fehmarn Sound seem to be due to geological formations. Mussels were shucked, freeze dried and homogenized. Elements were determined using INAA. NIST SRM 1571 (Orchard Leaves) and SRM 1577 (Bovine Liver), and Bowen's kale were analyzed as part of the QA protocol.

Year: 1979
Country: Germany
Source: 271

Species: *Mytilus edulis*
Number of sites: 33
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Fe), (Co), Ni, Zn, As, Se, (Br), Ag, Cd, (Au), Hg. PCBs.

Müller H., R. Schneider, and C. Schnier (1980) PCBs and metals in mussels from the western Baltic. ICES-CM-1980/E:52, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 2 pp.
Samples were collected along the east coast of Schleswig-Holstein, Germany, and anayzed for a suite of elements and total PCBs. Analysis was done using NAA. Elevated PCB levels were found in the harbour areas.

Year: 1979
Country: South Africa
Source: 116

Species: *Choromytilus meridionalis*
Number of sites: 1 (twice each)
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Ni, Cu, Zn, Cd, Pb

Orren, M. J., G. A. Eagle, H. F-K. O. Henning, and A. Green (1980) Variations in the trace metal content of the mussel *Choromytilus meridionalis* (Kr.) with season and sex. Mar. Pollut. Bull., 11(9):253-7.
Trace metal content of whole bodies of mussels are presented. The metal concentrations are correlated with each other and variations between individuals and sexes with season and stage in sexual cycle are discussed. The mussels were depurated prior to analysis. Tissue digestion was done using HNO_3 and $HClO_4$, and the digestates were analyzed using flame AAS.

Year: 1979
Country: Thailand
Source: 436

Species: *Mytilus viridis*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb. PCBs. Pesticides.

Menasveta, P., and V. Cheevaparanapiwat (1981) Heavy metals, organochlorine pesticides and PCBs in green mussels, mullets and sediments of river mouths in Thailand. Mar. Pollut. Bull., 12(1):19-25.
This study was undertaken to determine the levels of heavy metals and organic contaminants in mussels, mullet and sediment of the mouths of rivers in Thailand. Contamination of Pb was obvious. The mussels were frozen, dried and digested using HNO_3 and $HClO_4$. The digestates were analyzed using AAS. A separate digestion was done for Hg analysis and the digestates analyzed using CVAAS.

Year: 1979
Country: United States

Source: 139

Species: *Mytilus californianus*
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Zn, Pb

Loehr, L. C., and E. E. Collias (1983) Old cannery wastes a potential source of trace metals in the marine environment. Mar. Pollut. Bull., 14(10):392-394.
High levels of Pb and Zn were measured in the California mussel *Mytilus californianus* taken from southern Monterey Bay as part of the California State Mussel Watch program. The levels of Pb and Zn increase steadily from Cypress Point towards Cannery Row. The California State Water Resources Control Board, which funded but did not conduct the State Mussel Watch, has attributed the high levels to heavy metals contributed by sewage. Leachates from old cannery wastes may be a major source of Pb and Zn in mussels in southern Monterey Bay and must be considered in assessing any data from the State Mussel Watch program.

Year: 1979
Country: Yugoslavia

Source: 185

Species: *Mytilus galloprovincialis, Ostrea edulis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd, Pb

Martincic, D., H. W. Nürnberg, M. Stoeppler, and M. Branica (1984) Bioaccumulation of heavy metals by bivalves from Lim Fjord (North Adriatic Sea). Mar. Biol., 81(2):277-88.
Trace metal concentrations were studied in two different bivalve species of the same age, the mussel *Mytilus galloprovincialis*, Lmk., and the oyster *Ostrea edulis* which has been grown in the water of Lim Fjord, Yugoslavia, under the same physical conditions. Composite samples of tissue were dissolved using HNO_3 and $HClO_4$, and the subsequent solutions were analyzed using graphite furnace AAS. Results reported on a wet weight basis.

Year: 1979 - 1980
Country: Portugal

Source: 474

Species: *Mytilus edulis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Fe), Cu, Zn, Cd

Coimbra, J., and S. Carraça (1990) Accumulation of Fe, Zn, Cu, and Cd during the different stages of the reproductive cycle in *Mytilus edulis*. Comp. Biochem. Physiol., 95C(2):265-70.
Mussel specimens were collected at Vila Cha and Aguda beaches, on the northern coast of Portugal, to determine metal concentrations in the area. Gonad condition of the mussels was quantified. Composite samples of approximately 100 mussels of uniform size were dissolved using HNO_3 and the subsequent solutions analyzed using flame AAS. The analytical laboratory performing the analyses participated in the seventh ICES intercalibration exercise.

Year: 1979 - 1980
Country: Portugal
Source: 363

Species: *Mytilus edulis*
Number of sites: 5 (several times for two years)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Fe), Cu, Zn, Cd

Coimbra, J., S. Carraça, and A. Ferreira (1993) Metals in *Mytilus edulis* from the northern coast of Portugal. Mar. Pollut. Bull., 22(5): 249-53.
Mussel specimens were collected at five sites in Porto, on the northern coast of Portugal, to determine metal concentrations in the area. Sampling occurred several times during 1979 and 1980. Composite samples of approximately 100 mussels of uniform size were dissolved using HNO_3 and the subsequent solutions analyzed using flame AAS. The analytical laboratory performing the analyses participated in the seventh ICES intercalibration exercise. Only concentration ranges and graphical presentations of the monthly data were reported in the paper.

Year: 1979 - 1980
Country: Yugoslavia
Source: 715

Species: *Mytilus galloprovincialis*
Number of sites: 1 (monthly for two years)
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu

Martincic, D., H. W. Nürnberg and M. Branica (1987) Bioaccumulation of metals by bivalves from the Limski Kanal (North Adriatic Sea) III. Copper distribution between *Mytilus edulis galloprovincialis* (Lmk.) and ambient water. Sci. Total Environ., 60(-):121-4.
Cultured mussels of equal length were collected on a monthly basis except from January to March. The mussels were shucked and dissected into various tissue types. The dissected tissues were homogenized and then digested using HNO_3 and $HClO_4$. Results were reported as wet weight for the whole animals and the different tissue types. Seawater was also collected and analyzed as part of this study. Results reported on a wet weight basis.

Year: 1979 - 1980
Country: Yugoslavia
Source: 714

Species: *Mytilus galloprovincialis*, *Ostrea edulis*
Number of sites: 1 (monthly for two years)
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Zn

Martincic, D., M. Stoeppler and M. Branica (1987) Bioaccumulation of metals by bivalves from the Limski Kanal (North Adriatic Sea) IV. Zinc distribution between *Mytilus galloprovincialis*, *Ostrea edulis* and ambient water. Sci. Total Environ., 60(-): 143-72.
Cultured mussels and oysters of equal length were collected on a monthly basis except from January to March. The mussels were shucked and dissected into various tissue types. The dissected tissues were homogenized and then digested using HNO_3 and $HClO_4$. Results were reported as wet weight for the whole animals and the different tissue types. Seawater was also collected and analyzed as part of this study. Results reported on a wet weight basis.

Year: 1979 - 1981
Country: United States

Source: 134

Species: *Crassostrea virginica*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd, Pb

Sanders, M. (1984) Metals in crab, oyster and sediment in two South Carolina estuaries. Mar. Pollut. Bull., 15(4):159-61.
Four paired stations, selected according to salinities and proximity to urban areas, were sampled for blue crab, eastern oyster, and sediment in two estuaries near Charleston, SC, for a period of several months. Foster Creek receives heavy ship traffic, and industrial and municipal waste. St. Helena Sound receives little ship traffic or wastes. Composite oyster samples were digested with HNO_3 and the resulting digestates were analyzed using flame AAS and anodic stripping voltammetry. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the study. Temporal variations were found for Cd, Cu, Pb, and Zn in crab muscle, oyster tissue and sediment. Sediments and blue crabs were also analyzed as part of this study. Results reported on a wet weight basis.

Year: 1979 - 1983
Country: The Netherlands

Source: 868

Species: *Mytilus edulis*
Number of sites: 9
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb

Luten, J. B., W. Bouquet, M. M. Burggraaf, A. B. Rauchbaar, and J. Rus (1986) Trace metals in mussels (*Mytilus edulis*) from the Waddenzee, coastal North Sea and the estuaries of Ems, Western and Eastern Scheldt. Bull. Environ. Contam. Toxicol., 36(5):770-7.
This study is the Dutch contribution to the Joint Monitoring Programme for the assessment of marine pollution and the effectiveness of measures taken for its reduction. Mussels were shucked and homogenized. Lead and Cd were determined using ASV after digestion with HNO_3 and $MgNO_3$. Copper and Zn were determined using GFAAS and AAS, respectively, after digestion of the samples using HNO_3 and HCl. Mercury was determined using CVAAS.

Year: 1980
Country: Mexico

Source: 509

Species: *Crassostrea virginica*
Number of sites: 4
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, Cd, Hg, Pb

Rosas, I., A. Báez, and R. Belmont (1993) Oyster (Crassostrea virginica) as indicator of heavy metal pollution in some lagoons of the Gulf of Mexico. Water, Air, and Soil Pollut., 20:127-35.
The concentrations of Cr, Cd, Hg, and Pb were determined in water, sediment, and oysters collected in four coastal lagoons.

Year: 1980
Country: Oman
Source: 17

Species: *Crassostrea margaritacea, Perna perna*
Number of sites: 6
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Mg), (Al), V, Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, (Mo), Ag, Cd, (Sn), (Ba), Hg, Pb. HCs.

Burns, K. A., J. P. Villeneuve, V. C. Anderlin, and S. W. Fowler (1982) Survey of tar, hydrocarbon and metal pollution in the coastal waters of Oman. Mar. Pollut. Bull., 13(7):240-7.
Oysters and mussels, fish, sediments, and beach tar were collected as part of this study. The highest levels of tar in the world are on the coast of Oman. There is a trend of increasing levels of oil residues close to the strait of Hormuz. There was no indication of widespread metal contamination.

Year: 1980
Country: United States
Source: 158

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Hg

Breteler, R. J., J. M. Teal, and I. Valiela (1981) Bioavailability of mercury in several north-eastern U.S. *Spartina* ecosystems. Est. Coastal Shelf Sci., 12(2):155-66.
Mercury concentrations were measured in sediments, marsh grasses, mussels, and fiddler crabs (*Uca pugnax* and *U. minax*) in salt marsh plots treated with a mercury-containing commercial sludge fertilizer and in clear and industrially contaminated marshes.

Year: 1980 - 1981
Country: Ireland
Source: 415

Species: *Mytilus edulis*
Number of sites: 11
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Cd, Hg, Pb

Gault, N. F. S., E. L. C. Tolland, and J. G. Parker (1983) Spatial and temporal trends in heavy metal concentrations in mussels from Northern Ireland coastal waters. Mar. Biol., 77:307-16.
Data are presented on the heavy metal concentrations in mussels sampled over a one-year period from Northern Ireland. Homogenized composite tissue samples were ashed and dissolved using HNO_3 and HCl. The resulting digestates were analyzed using AAS. Mercury was analyzed using cold vapor AAS. The analytical laboratory participated in an ICES intercalibration exercise.

Year: 1980 - 1982
Country: Colombia

Source: 7 2

Species: *Crassostrea rhizophorae, Isognomon alatus, Isognomon isognomon*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Cd, Pb

Campos, N. H. (1988) Selected bivalves for monitoring of heavy metal contamination in the Colombian Caribbean. In: Metals in Coastal Environments of Latin America, Springer-Verlag, New York, 270-5.
Benthic bivalves were sampled along the Caribbean coast of Colombia. Samples collected during 1980 contained *Crassostrea rhizophorae, Isognomon alatus,* and *Donax denticulatus. Isognomon bicolor, C. rhizophorae* and *I. alatus* were obtained during four collection trips between April 1982 and 1983 which permitted the determination of maximum and minimum values. Dried samples were pulverized and subsequently analyzed for Cd, Cu, and Pb in the Institut für Meereskunde, Kiel, Germany. Samples were digested under high pressure and temperature in a teflon lined chamber using HNO_3. Metal concentrations in the digestates were determined using graphite furnace AAS. Only concentration ranges were reported for some sites.

Year: Taiwan
Country: 1980 - 1981

Source: 6 5 6

Species: *Crassostrea gigas*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Cd, Hg, Pb

Hung, T. C., C. Y. Kuo, and M. H. Chen (1981) Mussel watch in Taiwan, Republic of China (1) Bioaccumulative factors of heavy metals. A. Oceanogr. Taiwan, 12(-):67-83.
This paper is one of a series on the Mussel Watch effort of Taiwan. Clams, seawater, and sediments were also collected and analyzed as part of this effort. Tissues were digested using HNO_3 and H_2SO_4, and the digestates analyzed using ASV and AAS. Mercury was analyzed using CVAAS. Results reported on a wet weight basis.

Year: Taiwan
Country: 1980 - 1982

Source: 6 9 2

Species: *Crassostrea gigas*
Number of sites: 4
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Cd, Hg, Pb

Hung, T. C., C. Y. Kuo, and M. H. Chen (1983) Mussel watch in Taiwan, Republic of China. 2. Seasonal bioaccumulative factors of heavy metals. Bull. Inst. Chem., Acad. Sin., 30(-):49-62.
This paper is one of a series on the Mussel Watch effort of Taiwan. Tissues were digested using HNO_3 and H_2SO_4, and the digestates analyzed using ASV and AAS. Seawater was also collected and analyzed as part of this study.

Year: 1980 - 1987
Country: Taiwan

Source: 389

Species: *Crassostrea gigas*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu

Han, B. C., and T. C. Hung (1990) Green oysters caused by copper pollution on the Taiwan coast. Environ. Pollut., 65:347-62.

The first case of green oysters broke out along one of the mariculture areas of Taiwan in 1986. The green color was due to high Cu content. Specimens were shucked, dried, and digested using HNO_3 and H_2SO_4. The digestates were analyzed using AAS. NIST SRM 1566 (Oyster) was analyzed as part of the QA protocol. Results reported on a wet weight basis.[The 1980 - 1986 data presented in the paper was from a previous study by Hung *et al.* (Hung, T. C., C. Y. Kuo, and M. H. Chen (1981) Mussel Watch in Taiwan, Republic of China (1) Bioaccumulative factors of heavy metals. Acta Oceanogr. Taiwanica, 12:67-83.)]

I.10. **1981 - 1990**

Year: 1981
Country: Australia

Source: 23

Species: *Mytilus edulis*
Number of sites: 15
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Cd, Hg, Pb

Talbot, V. (1983) Lead and other trace metals in the sediments and selected biota of Princess Royal Harbour, Albany, Western Australia. Environ. Pollut. (Ser. B), 5(1):35-49.
Results of a survey of Ag, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, and Zn in sediments and biota from Princess Royal Harbour, Albany, Western Australia, are reported. Tissue samples were digested using HNO_3 and the digestates analyzed using AAS. Sediments contained elevated levels of Pb. Elevated metal levels were not found in the mussels and this may due to the sampling location of the bivalves which was near the top of the water column. Results reported on a wet weight basis.

Year: 1981
Country: Belgium

Source: 433

Species: *Mytilus edulis*
Number of sites: 14
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Hg, Pb

Meeus-Verdine, K., R. Van Cauter and R. de Borger (1983) Trace metal content in Belgian coastal mussels. Mar. Pollut. Bull., 14(5):198-200.
The specimens were shucked, mixed, dried, and calcinated. The ashes were digested using HNO_3 and H_2O_2 and the subsequent digestate analyzed using AAS. Mercury was determined using CVAAS.

Year: Denmark
Country: 1981

Source: 140

Species: *Mytilus edulis*
Number of sites: 5
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Hg

Kiørboe, T., F. Mohlenberg, and H. U. Rüsgard (1983) Mercury levels in fish, invertebrates and sediments in a recently recorded polluted area (Nissum Broad, Western Limfjord, Denmark). Mar. Pollut. Bull., 14(1):21-4.
Mussels, other invertebrates, fish, and sediment were collected in the immediate vicinity of a closed down chemical factory of pesticides, herbicides, and Hg-containing fungicides. The specimens were analyzed for Hg. The Hg concentrations rapidly decreased with increasing distance from the former factory. Sediment and other species were also collected and analyzed as part of this study. Results reported on a wet weight basis.

Year: 1981
Country: Poland
Source: 393

Species: *Mytilus edulis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mg), (Ca), (Mn), (Fe), (Co), Ni, Cu, Zn, Cd, Pb

Szefer, P., K. Szefer (1985) Occurrence of ten metals in *Mytilus edulis* L. and *Cardium glaucum* L. from the Gdansk Bay. Mar. Pollut. Bull., 16(11):446-50.
The determination of major and minor elements was carried out in the soft tissues and shells of *Mytilus edulis* and *Cardium glaucum* from Gdansk and Puck Bay. This paper reports on the influence of size (age) on the metal concentration of molluscs. The tissue samples were treated with HNO_3 and $HClO_4$. The resulting solution was passed through an anion exchange column. Element concentrations were determined using AAS. Both species-dependent variability and regional variations of metal concentrations in molluscs were observed. The correlation coefficients between the concentrations of metal in the soft tissues and shells were determined.

Year: 1981
Country: Taiwan
Source: 692

Species: *Crassostrea gigas*
Number of sites: 4
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Cd, Hg, Pb

Hung, T-C., C-Y. Kuo, and M-H. Chen (1983) Mussel watch in Taiwan, Republic of China. 2. Seasonal bioaccumulative factors of heavy metals. Bull. Inst. Chem., Acad. Sin., 30(-):49-62.
Oysters were digested using HNO_3 and H_2SO_4 and the digestates analyzed using ASV and AAS.

Year: Korea
Country: 1981 - 1982
Source: 90

Species: *Mytilus edulis*
Number of sites: 15
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), Cu, Zn, Cd, Pb

Lee, S. H., and K. W. Lee (1984) Heavy metals in mussels in the Korean coastal waters. J. Oceanol. Soc. Korea, 19(2):111-7.
Heavy metal contents in soft tissues of mussels, *Mytilus edulis,* of Imweon, Banweol, Jinhae Bay, and Yeosu in Korea were determined during 1981 and 1982. The mussels were depurated immediately after collection. Dried tissue composites were charred in a furnace and dissolved in HNO_3. The resulting solutions were analyzed FAAS or GFAAS.

Year: 1981 - 1982
Country: New Zealand

Source: 227

Species: *Tiostrea lutaria*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), Cu, Zn, Se, Cd

McKenzie-Parnell, J. M., T. E. Kjellstrom, R. P. Sharma, and M. F. Robinson (1988) Unusually high intake and fecal output of cadmium, and fecal output of other trace elements in New Zealand adults consuming dredge oysters. Env. Res., 46:1-14.

The concentration of Cd in the New Zealand oyster *Tiostrea lutaria* was sufficiently high so that ingestion of just one oyster can more than double the normal daily dietary intake of Cd for an adult. Pre-season and end-season assessments of dietary intake and fecal output were used in this study to determine the effects of consumption of oysters. Oyster specimens were analyzed to determine their Cd content. Composite tissue samples were digested using HCl and the digestate analyzed for Cd using flame AAS. NIST SRM 1577 (Bovine Liver) was used as part of the quality assurance protocol.

Year: 1981 - 1982
Country: United States

Source: 746

Species: *Mytilus edulis*
Number of sites: 4
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd

Franson, J. C., P. S. Koehl, D. V. Derksen, T. C. Rothe, C. M. Bunck, and J. F. Moore (1995) Heavy metals in seaducks and mussels from Misty Fjords National Monument in southeast Alaska. Environ. Monit. Assess., 36(-):149-67.

Quartz Hill in Misty Fjords national Monument near Ketchikan, AK, is the site of a proposed molybdenum mine. This study was carried out to document levels of trace elements that could potentially be released into the environment as the result of mining operations. Mussels were allowed to depurate, were shucked, and frozen. Ashed tissue samples were analyzed using AAS. Barrow's goldeneyes and common mergansers were also analyzed as part of this study.

Year: 1982?
Country: England

Source: 26

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, Ni Cu, Zn, Cd, Hg, Pb. (DDTs), (Pesticides).

Gould, D. J., M. F. Dyer, and D. J. Tester (1987) Environmental quality and ecology of the Great Ouse estuary. Water Pollut. Control, 86(1):84-103.

This paper described an ecological study to assess the condition of the Great Ouse Estuary and the decline of the local fisheries. Only the mean concentrations on a wet weight basis for mussels were reported in the paper. Other species, sediment, and seawater were also collected and analyzed.

Year: 1982
Country: Thailand
Source: 884

Species: *Crassostrea commercialis, Perna viridis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, Cu, Zn, Cd, Pb

Hungspreugs, M., and C. Yuangthong (1984) Present levels of heavy metals in some molluscs of the Upper Gulf of Thailand. Water, Air, Soil Pollut., 22(4):395-402.
This investigation was carried out as part of Thailand's participation in the global "Mussel Watch" program. Mussels and oysters were collected, washed, and shucked. The tissues were dried and digested using HNO_3. The digestates were analyzed using GFAAS and AAS. Cockels were also collected and analyzed. Data mean and/or range reported on a dry weight basis.

Year: 1982
Country: United States
Source: 511

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: Yes
Analytes: Cu, Zn, Ag, Cd, Hg

Roesijadi, G., J. S. Young, A. S. Drum, and J. M. Gurtisen (1984) Behavior of trace metals in *Mytilus edulis* during a reciprocal transplant field experiment. Mar. Ecol., 18(1-2):155-170.
This was a reciprocal transplant study between sites in Tacoma and Sequim, WA. Only the initial condition trace metal levels were added to the database. NIST oyster tissue SRM was analyzed as part of this study (SRM number not specified).

Year: 1982
Country: Wales
Source: 879

Species: *Crassostrea angulata, Ostrea edulis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd

Frazier, J. M., and S. G. George (1983) Cadmium kinetics in oysters - a comparative study of *Crassostrea gigas* and *Ostrea edulis*. Mar. Biol., 76(-):55-61.
Accumulation of Cd was investigated in two species of oysters from one location, and in oysters of the same species collected at two locations. Oysters were shucked, homogenized, and digested using HNO_3. The digestates were analyzed using AAS.

Year: 1982 - 1983
Country: Thailand
Source: 283

Species: *Crassostrea commercialis, Perna viridis*
Number of sites: 21
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Fe), Ni, Cu, Zn, Cd, Hg, Pb

Phillips, D. J. H., and K. Muttarasin (1985) Trace metals in bivalve molluscs from Thailand. Mar. Environ. Res., 15(3):215-34.
Samples were collected from commercial beds or markets. Composite tissue samples digested with HNO_3 and H_2SO_4 and the subsequent solutions analyzed using flame or graphite furnace AAS for all elements except Hg which was analyzed using vapor generation AAS. NIST SRM 1566 (Oyster Tissue) and RM 50 (Tuna Homogenate) and intercomparison materials from IAEA

and ICES were analyzed as part of the QA protocol. Other species collected and analyzed were clams (*Paphia undulata*) and cockles (*Anadara granosa*).

Year: 1982 - 1985
Country: France
Source: 65

Species: *Crassostrea gigas*
Number of sites: 9
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Sn

Alzieu, C., J. Sanjuan, J. P. Deltreil, and M. Borel (1986) Tin contamination in Arcachon Bay: effects on oyster shell anomalies. Mar. Pollut. Bull., 17(11):494-8.
Total Sn and organotin levels in both seawater and oysters from Arcachon Bay, and the frequency of shell anomalies were monitored since the ban of organotin antifouling paints in 1982. The results show that at the end of the survey period in 1985, Sn levels in areas of organotin input were 5 to 10 times lower than those found in 1982.

Year: 1983
Country: Australia
Source: 316

Species: *Saccostrea cucullata*
Number of sites: 8
Analytical methodology?: In cited paper
Quality assurance?: Yes
Analytes: (Ti), Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, As, (Br), (Sr), (Y), (Mo), Cd, Sn, (Te), (La), (Yb), (Hf), (Th)

Talbot, V., and W.-J. Chang (1987) Rapid multielement analysis of oyster and cockle tissue using x-ray fluorescence spectrometry, with applications to reconnaissance marine pollution investigations. Sci. Total Environ., 66(-):213-23.
Mussel and cockle tissues were analyzed for a variety of elements using XRF. NIST SRMs 1566 (Oyster Tissue), 1571 (Orchard Leaves), 1573 (Tomato Leaves) and 1575 (Pine Needles) were used as part of the quality assurance protocol. Concentrations means and ranges of six individuals measurements on three bulk samples were reported.

Year: 1983
Country: Denmark, Germany
Source: 101

Species: *Mytilus edulis*
Number of sites: 32
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, Ni, Cu, Zn, As, Cd, Hg, Pb

Jensen, A. (1985) Geographical trends in the concentrations of heavy metals in blue mussels from the German Bight to Hirtshals in 1983. Preliminary report. ICES-CM-1985/E:44, International Council for the Exploration of the Sea, Copenhaguen, Denmark, 4 pp.
Blue mussels, *Mytilis edulis,* were sampled at 32 stations from the German Bight to the northern part of Jutland in May 1983.

Year: 1983
Country: Hong Kong
Source: 144

Species: *Perna viridis*
Number of sites: 15
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd, Hg, Pb. PCBs.

Phillips, D. J. H. (1985) Organochlorines and trace metals in green-lipped mussels *Perna viridis* from Hong-Kong waters: a test of indicator ability. Mar. Ecol., 21(3):251-8.
This paper is a study of the suitability of the green-lipped mussel an indicator of pollution. Mussels were homogenized and digested using HNO_3. The subsequent digestates were analyzed for all elements except Hg using AAS or GFAAS. A separate aliquot of the homogenate was digested with HNO_3 and H_2SO_4. Potassium permanganate and H_2O_2 were then added to the digestates. Stannous chloride was added and the Hg measured using CVAAS. NIST RM 50 (Tuna Homogenate) was analyzed as part of the QA protocol.

Year: 1983
Country: Indonesia
Source: 876

Species: *Mytilus viridis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cd, Hg

Hutagalung, H. P. (1989) Mercury and cadmium content in green Mussel, *Mytilus viridis* L. from Onrust Waters, Jakarta Bay. Bull. Environ. Contam. Toxicol., 42(6):814-20.
Mussels were collected biweekly from Jakarta Bay and allowed to depurate. The mussels were then shucked and digested using HNO_3 and H_2O_2. Total Hg was determined after addition of Sn Cl_2 using CVAAS. Cadmium was determined using AAS. Seawater was also collected as part of this study. Data mean and/or range reported on a dry weight basis.

Year: 1983
Country: Italy
Source: 741

Species: *Mytilus galloprovincialis, Brachidontes variabilis*
Number of sites: 10
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Fe), Ni, Cu, Zn, Cd, Hg, Pb

Castagna, A., F. Sinatra, G. Castagna, A. Stoli, and S. Zafarana (1985) Trace element evaluations in marine organisms. Mar. Pollut. Bull., 16(10):416-19.
The Bay of Augusta, Sicily, receives discharges of various kinds: industrial discharge from the petroleum industry, urban sewage sludge, and port discharges. To assess the environmental conditions of the area, algae and animals were sampled in 1983. The mussel tissues were dried and digested using $HClO_4$ and HNO_3 and the subsequent solutions analyzed using AAS.

Year: 1983
Country: United States
Source: 831

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn

Phelps, H. L., and E. W. Hetzel (1987) Oyster size, age, and copper and zinc accumulation. J. Shellfish Res., 6(2):67-70.
Copper and zinc and growth parameters were measured in two artificially spawned sets of oysters raised in Chesapeake Bay. The specimens were shucked and the tissue rinsed, blotted, dried, and digested using HNO_3. Analysis of the digestates was done using AAS. Results reported on a wet weight basis.

Year: 1983
Country: United States
Source: 201

Species: *Mytilus edulis*
Number of sites: 9
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cu, Cd. PCBs.

Greig, R. A., and G. Sennefelder (1985) Metals and PCB concentrations in mussels *Mytilus edulis* from Long Island Sound. Bull. Environ. Contam. Toxicol., 35(3):331-4.
Metals and PCBs are contaminants of concern in Long Island Sound. For this study, mussels were collected from the mouths of various rivers and inshore areas along the Connecticut shoreline and analyzed for Cu, Cd, and PCBs. Results reported on a wet weight basis.

Year: 1983
Country: United States
Source: 633

Species: *Crassostrea virginica*
Number of sites: 1?
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Na), (Mg), (K), (Ca), Cr, (Fe), Ni, Cu, Zn

Hackney, C. R., S. L. Biede, P. Arbour, L. Reily, M. Kilgen and M. Cole (1987) Variation in the levels of sodium and other minerals of nutritional importance in Louisiana oysters (Crassostrea virginica). J. Food Sci., 52(4):1099-100.
Concentrations of nine elements were determined in oysters collected once a month over a 10-month period. The specimens were collected from oyster beds in Terrebone Parish, Louisiana. The oysters were shucked, homogenized, and digested using HNO_3. The digestates were analyzed using ICP-MS. Results reported on a wet weight basis.

Year: 1983
Country: United States

Source: 720

Species: *Crassostrea gigas*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, Ni, Cu, Zn, Cd, Hg, Pb

Mann, R., and R. E. Taylor (1983) Public health aspects of the culture of the Japanese oyster *Crassostrea gigas* (Thunberg) in a waste recycling aquaculture system. Aquaculture, 30(1-4):311-27.
This was an exposure study and only the initial levels of heavy metals in the control specimens were included in the database. The oyster tissues were freeze dried, digested using HNO_3, and the resulting solutions analyzed using GFAAS.

Year: 1983 - 1984
Country: Australia

Source: 314

Species: *Saccostrea cucullata*
Number of sites: 8
Analytical methodology?: In cited paper
Quality assurance?: Yes
Analytes: Cu, Zn

Talbot, V. (1986) Seasonal variation of copper and zinc concentrations in the oyster *Crassostrea cucullata* from the Dampier Archipelago, Western Australia: implications for pollution monitoring. Sci. Total Environ., 57(-):217-30.
In the study area, Cu and Zn emanate from sewage and boat slips (antifouling paints), while Zn probably also originates from coolant water from an electricity power generating station and iron ore exporting facilities. Highest oyster wet weights, Cu and Zn concentrations and loads occurred in January, the spawning period, indicating that metal variation was not reciprocating wet weight. Lowest metal concentrations and loads occurred in October, at the time of the onset of gametogenesis, while lowest wet weight occurred in April, the past spawning period. NIST SRMs 1566 (Oyster Tissue) was used as part of the quality assurance protocol. Data mean and/or range reported on a dry weight basis.

Year: 1983 - 1984
Country: Croatia

Source: 891

Species: *Mytilus galloprovincialis, Ostrea edulis*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Hg

Najdek, M., and J. Sapunar (1987) Total and methylmercury content in bivalves, *Mytilus galloprovincialis* Lamarck and *Ostrea edulis* Linnaeus: relationship of biochemical composition and body size. Bull. Environ. Contam. Toxicol., 39(1):56-62.
This paper investigates the relationship between total and methylmercury content and body mass in mussel and oysters collected in the Limski Canal.

Year: 1983 - 1984
Country: United States

Source: 840

Species: *Crassostrea virginica Brachidontes exustus*
Number of sites: 6
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cr, Cu, Zn, As, Ag, Cd, Hg, Pb

Ramelow, G. J., C. L. Webre, C. S. Mueller, J. N. Beck, J. C. Young, and M. P. Langley (1989) Variations of heavy metals and arsenic in fish and other organisms from the Calcasieu River and Lake, Louisiana. Arch. Environ. Contam. Toxicol., 18:804-18.
Heavy metals and As were determined in fish and other organisms from Calcasieu Lake, LA. Concentrations of all elements measured in both intra and interspecies showed no significant variation with sample location. Difference in elemental concentration were related to organism mobility. Sessile organisms had the highest concentrations of heavy metals. Bivalve specimens wer frozen, thawed, shucked, and dried. The dried tissues were digested using HNO_3 and the digestates analyzed using AAS, GFAAS, or CVAAS. Reference samples from IAEA and water reference standards from a commercial laboratory were analyzed as part of the QA protocol.

Year: 1984
Country: Portugal

Source: 390

Species: *Mytilus galloprovincialis*
Number of sites: 48
Analytical methodology?: NA
Quality assurance?: NA
Analytes: (Mn), (Fe), Cr, Ni, Cu, Zn, Cd, Pb. PCBs.

Vale C., A. M. Ferreira, C. Cortesão, M. C. Barros, O. G. Castro, and R. Mendes (1985) A mussel watch in the Portuguese coast, 1984. CM 1985/E:18, ICES, 19 pp.
This is the first Mussel Watch project conducted along the coast of Portugal. The mussels were depurated and frozen. The specimens were slightly thawed, shucked, freeze dried, and pulverized. The tissue material was homogenized and digested using HNO_3. The digestates were analyzed using AAS and GFAAS.

Year: 1984
Country: Scotland

Source: 753

Species: *Mytilus edulis*
Number of sites: 16
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), Ni, Cu, Zn, Cd, Hg, Pb

Miller, B. S. (1986) Trace metals in the common mussel *Mytilus edulis* (L.) in the Clyde estuary. Proc., Royal Soc. Edinburgh (Sec. B, Biol. Sci.), 90(-):377-91.
Blue mussels were sampled at 16 sites in the Clyde Estuary as part of the Clyde River Purification Board Mussel Watch Program. This paper discusses the results of the 1984 survey. Mussels were collected and allowed to depurate. Shucked mussels were pooled, dried, ground, and stored until analysis. Samples were digested using HNO_3 with subsequent addition of HCl, and the digestates analyzed using AAS for all elements except Hg which was analyzed using atomic fluorescence. The analytical laboratory participated in ICES intercomparison exercises.

Year: 1984
Country: Scotland
Source: 908

Species: *Crassostrea gigas*
Number of sites: 10
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Sn

Davies, I. M., J. C. McKie, and J. D. Paul (1986) Accumulation of tin and tributyltin from antifouling paint by cultivated scallops (*Pecten maximus*) and Pacific oysters (*Crassostrea gigas*). Aquaculture, 55(-):103-14.
The accumulation of Sn and tributyltin in oysters and scallops from anti-fouling paint was investigated.

Year: 1984?
Country: Singapore
Source: 906

Species: *Perna viridis*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Pb

Tan, W. H., and L. H. Lim (1984) The tolerance to and uptake of lead in the green mussel, *Perna viridis* (L.). Aquaculture, 42(-):317-32.
Lead concentrations were determined in the tissues of green mussels after exposure to Pb. Only initial conditions were added to the database. Results reported on a wet weight basis.

Year: 1984
Country: Thailand
Source: 403

Species: *Ostrea plicatula, Perna viridis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Co), Ni, Cu, Cd, Pb. PAHs

Hungspreugs, M., S. Silpipat, C. Tonapong, R. F. Lee, H. L. Windom, and K. R. Tenore (1984) Heavy metals and polycyclic hydrocarbon compounds in benthic organisms of the Upper Gulf of Thailand. Mar. Pollut. Bull., 15(6):213-8.
Concentrations of heavy metals and PAHs were measured in bivalves collected in the Upper Gulf of Thailand. Tissues for metal analysis were digested using concentrated HNO_3 and $HClO_4$. The digestates were analyzed using AAS. NIST SRM 1577 (Bovine Liver) and the ICES Fish Meal reference material were used as part of the QA protocol for metal analysis. Concentrations of Cd, Co, Cu, Pb, and Ni were significantly lower in bivalves from the Gulf than in green mussels collected from the mouth of the Chao Phraya River. No correlation was found between metal concentrations in animals and sediment, with the exception of Cu. Other species were collected and analyzed.

Year: 1984 - 1986
Country: Argentina

Source: 111

Species: *Aulacomya ater, Mytilus platensis*
Number of sites: 1 (sampled during several months), 1 (sampled once)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), (Fe), Ni, Cu, Zn, Cd, Pb

Gil, M. N., M. A. Harvey, and J. L. Esteves (1988) Metal content in bivalve molluscs from the San José and Nuevo Gulfs, Patagonia, Argentina. Mar. Pollut. Bull., 19(4):181-2.
Bivalve samples were collected by divers, and composite samples were prepared for analysis. Samples were digested using concentrated HNO_3 in a Teflon high pressure decomposition vessel. Metal measurements were made using AAS by the method of standard addition. Fifteen bivalves from each species and population were analyzed individually to calculate the typical variation coefficients. Specimens of the scallop *Chlamys tehuelcha* were also collected and analyzed. Only concentration ranges reported for one sampling site. Other species were sampled as part of this study. Range data was reported for one site.

Year: 1984 - 1985
Country: Brazil

Source: 76

Species: *Mytela falcata*
Number of sites: 1 (3 different times)
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Hg, Pb

Juras, A. A. (1988) A preliminary survey of heavy metal concentrations in some estuarine organisms in the littoral zone of São Luis Island, Maranhão, Brazil. Metals in Coastal Environments of Latin America, Springer-Verlag, New York, 16-20.
Samples of molluscs such as the mussel *Mytela falcata* and fish like *Genyatremus luteus, Arius herzbergi* and *Mugil curema* are of economic importance and are very abundant in the littoral of São Luis Isl. With the recent industrialization of the south of the island by companies such as ALCOA and COMPANHIA VALE DO RIO DOCE which process aluminum and iron ore respectively, much interest has been focused on toxic metals and other elements in species of economic importance. The present paper described preliminary studies of metal concentrations in some estuarine organisms of economic importance to the people of São Luis Isl. Metals were analyzed using AAS.

Year: 1984 - 1987
Country: England, Wales

Source: 434

Species: *Mytilus edulis*
Number of sites: 68?
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Hg, Pb.

Ministry of Agriculture, Fisheries and Food (1990) Monitoring and surveillance of non-radioactive contaminants in the aquatic environment, 1974 - 1987. Aquatic environment monitoring response no. 22, MAFF Directorate of Fisheries Research, Lowestoft, UK, 60 pp.
This is the part of a series recording the results of the fish and shellfish monitoring program. Location of sites listed only as ICES rectangles. Results reported on a wet weight basis.

Year: 1985
Country: Chile
Source: 897

Species: *Mytilus chilensis, Aulacomya ater*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Fe), Ni, Cu, Zn, Se

Ober, A. G., M. Gonzalez, and I. Santa Maria (1987) Heavy metals in molluscan, crustacean, and other commercially important Chilean marine coastal water species. Bull. Environ. Contam. Toxicol., 38(3):534-9.
Although considerable data has been accumulated on the distribution and levels of heavy metals in the marine environment, there is little data available for the southern eastern Pacific coast. This paper described an effort to monitor the coast of Chile using mussels and other species. Tissues were digested using HNO_3, H_2SO_4, and H_2O_2, and the digestates analyzed using AAS. Selenium was analyzed using hydride generation.

Year: 1985
Country: Chile
Source: 904

Species: *Mytilus chilensis, Aulacomya ater*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: As

Santa Maria, I., M. Gonzalez, W. Lara, and A. Ober (1986) Arsenic levels in Chilean marine species. Bull. Environ. Contam. Toxicol., 37(4):593-8.
This paper describes the analysis of As of the species collected by Ober *et al.* (1987). Arsenic was analyzed by hydride generation.

Year: 1985
Country: Scotland
Source: 912

Species: *Crassostrea gigas*
Number of sites: 1
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Al), Cr, (Mn), Cu, Zn, Ag, Cd

Davies, I. M., J. Drinkwater, and J. C. McKie (1988) Effects of tributyltin compounds from antifoulants on Pacific oysters (*Crassostrea gigas*) in Scottish sea lochs. Aquaculture, 74:319-30.
Prior to 1987, tributyltin-based antifoulant paints were used in Scottish sea lochs on hulls of vessels and on cage nets at marine salmon farms. Leacheates from the paints caused deleterious effects on oyster cultures. Oysters from a nursery in Colonsay Isl. were transplanted to the two lochs under study and sampled at various time intervals. Only the initial Sn concentrations were added to the database. Tin determinations were made using GFAAS. Data mean and/or range reported on a wet weight basis.

Year: 1985 - 1986
Country: Mexico
Source: 85

Species: *Modiolus capax*
Number of sites: 3 (2 samplings)
Analytical methodology?: In cited paper
Quality assurance?: Yes
Analytes: (Al), Cr, (Mn), Cu, Zn, Ag, Cd

Gutiérrez Galindo, E. A., G. Flores Muñoz, G. Olguín Espinoza, and J. Villaescusa Celaya (1990) Biodisponibilidad de metales traza en almejas y mejillon del valle agricola de Mexicali y Alto Golfo de California (Bioavailability of trace metals in clams and mussels of the agricultural valley of Mexicali and upper Gulf of California). Cienc. Mar., 16(4):1-28 (English/Spanish).
The bioavailability of Zn, Cu, Mn, Ag, Al, Cd, and Cr in the agricultural valley of Mexicali, Baja California, was studied in order to diagnose the contamination by these metals in the waters of these areas. Specimens of the clam *Corbicula fluminea* were collected from the agricultural valley, and of the clam *Chione californiensis* and the mussel *Modiolus capax* from the upper Gulf of California. Quantification of metals in the digestate was done using AAS. NIST SRM 1571 (Orchard Leaves) and SRM 1577 (Bovine Liver) were analyzed as part of the study.

Year: 1985 - 1986
Country: Mexico
Source: 902

Species: *Saccostrea iridescens*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Al), Cr, (Mn), Cu, Zn, Ag, Cd

Páez Osuna, F., and C. Marmolejo Rivas (1990) Occurrence and seasonal variation of heavy metals in the oyster *Saccostrea iridescens*. Bull. Environ. Contam. Toxicol., 44(-):129-34.
This is a study of the level of trace metals in *Saccrostrea iridescens* specimens collected on the northwest coast of Mexico, a rural uncontaminated area. Tissues were dissolved using HNO_3 and the digestates analyzed using AAS. IAEA MA-M-2/TM (Mussel Tissue) was analyzed as part of the QA protocol.

Year: 1985 - 1986
Country: New Zealand
Source: 865

Species: *Crassostrea gigas*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Fe), Ni, Cu, Zn, Ag, Cd, Pb

Auckland Regional Water Board (1987) N. Z. Steel Limited environmental monitoring Program. First Annual Rep. 1985 - 1986. Tech. Pub. 44, Auckland Regional Water Board, Auckland, New Zealand, 19 pp.
This is one of a series of reports on monitoring the impact of discharge by New Zealand Steel Ltd. into Manukau Harbour, New Zealand.

Year: 1985 - 1987
Country: Greenland

Source: 385

Species: *Mytilus edulis*
Number of sites: 2
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Zn, Pb

Asmund, G., P. Johansen, and B. W. Fallis (1991) Disposal of mine wastes containing Pb and Zn near the ocean: an assessment of associated environmental implications in the Arctic. Chem. Ecol., 5(-):1-15.
Tailings and waste rock containing Pb and Zn have been disposed of at several locations in the Arctic. At Maarmorilik, Greenland, mining for Zn and Pb commenced in 1973. Tailings are disposed at sea or allowed to come in contact with seawater. Increases in the level of Zn and Pb in the seawater of the fjord were found. Mussels were frozen, dry ashed, digested in HNO_3 and analyzed using AAS. Seawater, sediment, and other species were also collected and analyzed.

Year: 1985 - 1987
Country: Yugoslavia

Source: 424

Species: *Mytilus galloprovincialis*
Number of sites: 7
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Hg

Mikac, N., Z. Kwokal, K. May, and M. Branica (1989) Mercury distribution in the Krka river estuary (eastern Adriatic coast). Mar. Chem., 28(1-3):106-26.
The distributions of total and organic Hg in water, sediments, and mussels from the Krka River estuary and the Kornati Archipelago were determined. Composite samples of tissue were digested using HNO_3 and the resulting solutions analyzed using cold vapor AAS. The results suggested that the study areas were uncontaminated. Results reported on a wet weight basis.

Year: 1986
Country: Australia

Source: 44

Species: *Saccostrea cucullata*, *Saccostrea echinata*
Number of sites: 7
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Fe), Ni, Cu, Zn, Cd, Pb

Peerzada, N., and C. Dickinson (1989) Metals in oysters from the Arnhem Land coast, Northern Territory, Australia. Mar. Pollut. Bull., 20(3):144-5.
Specimens of *Saccostrea cucullata* and *Saccostrea echinata* were collected in Arnhem Land and Darwin. The oysters were frozen in the shell. When defrosted, the oysters were shucked, drained and digested using HNO_3. The digestates were analyzed using AAS. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the QA protocol. Data mean and/or range reported on a wet weight basis.

Year: 1986
Country: Denmark
Source: 86

Species: *Mytilus edulis*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Sn

Zoulian, C., and A. Jensen (1989) Accumulation of organic and inorganic tin in blue mussel, *Mytilus edulis*, under natural conditions. Mar. Pollut. Bull., 20(6):281-6.
The aim of the study was to follow the uptake of organic and total tin in *Mytilus edulis*, under natural conditions in a marina contaminated with organic tin compounds released from antifouling paints used on pleasure boats. The accumulation of organic and total tin was studied over a period of 51 days with simultaneous sampling of seawater for organic and total Sn analyses. Seawater was also analyzed as part of this study. Only the Sn concentrations in the mussels prior to exposure were included in the database.

Year: 1986
Country: Hong Kong
Source: 48

Species: *Perna viridis*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Chan, H. M. (1989) Temporal and spatial fluctuations in trace metal concentrations in transplanted mussels in Hong Kong. Mar. Pollut. Bull., 20(2):82-6.
The levels of Cu, Zn, Cd, and Pb in green mussels collected in Hong Kong waters were determined. The specimens were shucked, homogenized and digested using HNO_3. The digestates were analyzed using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1986
Country: Hong Kong
Source: 473

Species: *Perna viridis*, *Saccostrea cucullata*
Number of sites: 9
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Fe), Cu, Zn, Cd, Pb

Chu, K. H., W. M. Cheung, and S. K. Lau (1990) Trace metals in bivalves and sediments from Tolo Harbour, Hong Kong. Environ. Internatl., 16(1):31-6.
Concentrations of Fe, Cu, Zn, Cd, and Pb were determined in samples of sediments, mussel, and rock oyster from nine locations in Tolo Harbour, Hong Kong. The concentrations of metals in bivalves did not vary greatly from one location to another and showed no correlation with the concentrations in sediments. Tissue samples were digested using $HClO_4$, HNO_3, and H_2SO_4 and the digestates analyzed using flame AAS.

Year: 1986
Country: Italy
Source: 8

Species: *Mytilus galloprovincialis*
Number of sites: 136
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cd, Hg, Pb

Giordano, R., P. Arata, L. Ciaralli, S. Rinaldi, M. Giani, A. M. Cicero, and S. Costantini (1991) Heavy metals in mussels and fish from Italian coastal waters. Mar. Pollut. Bull., 22(1):10-4.
Concentrations of Hg, Cd, and Pb were determined in the soft tissue of four types of marine organisms (*Mytilus galloprovincialis*, *Murex trunculus*, *Serranus scriba* and *Serranus cabrilla*), collected along the Italian coasts from Genoa (Ligurian Sea) to Termoli (Adriatic Sea) in the summer of 1986. The analyses were performed by the electrothermal (Cd and Pb) and cold vapour (Hg) AAS techniques. Samples were collected at a series of 34 stations and 102 substations along the Italian coast totaling 136 sampling sites. Values for 20 stations were reported in the paper. Sampling, handling and specimen storage were followed as described by FAO. NIES No. 6 (Mussel) and NRC BCSS-1 (Marine Sediment) were used as reference materials. Blanks coefficients of variation and detection limits are listed.

Year: 1986?
Country: New Zealand
Source: 678

Species: *Mytilus edulis, Perna canaliculus, Aulacomya maoriana, Atrina novazealandia, Tiostria lutaria*
Number of sites:
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (P), (Mg), (Al), (Si), (K), (Ca), (Ti), (V), Cr, (Mn), (Fe), Ni, Cu, Zn, As, (Zr), (Mo), Cd, (Rb), (Sr), (Ba), Pb, Hg

Kennedy, P. C. (1986) The use of mollusks for monitoring trace elements in the marine environment in New Zealand 1. The contribution of ingested sediment to the trace element concentrations in New Zealand mollusks. N. Z. J. Mar. Freshwater Res., 20(4):627-40.
Mussels, oysters, a mud snail, and sediment were collected at various locations in New Zealand to calculate the effect of sediment in the gut on the estimation of total body burden of mollusks. The bivalves were cleaned, depurated, and frozen in shell. The specimens were then thawed, shucked and freeze dried. The freeze dried material was ground and prepared for XRF analysis of some elements. Cadmium, Cr, Hg, and Pb were analyzed using AAS after further extraction as needed. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the analytical protocol.

Year: 1986
Country: Yugoslavia
Source: 38

Species: *Mytilus galloprovincialis, Ostrea edulis*
Number of sites: 1 (mussels), 1 (oysters)
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: As, Cd, Hg, Pb

Ozretic, B., M. Krajnovic Ozretic, J. Santin, B. Medjugorac, and M. Kras (1990) As, Cd, Pb, and Hg in benthic animals from the Kvarner-Rijeka Bay region, Yugoslavia. Mar. Pollut. Bull., 21(12):595-8.
The northern part of the Rijeka Bay, Yugoslavia, is one of the most heavily industrialized regions of the eastern Adriatic coast. Analyses have indicated that some samples of fish routinely taken from the fish market contained notable concentrations of toxic metals. The presence of extremely high concentration of arsenic was noted in particular. Bakar Bay, in

general was chosen as representative of a heavily polluted marine environment. Specimen composites were prepared if necessary. The tissues were digested at high pressure and temperature with HNO_3. Cd and Pb were determined using graphite furnace AAS; Hg using cold vapor AAS; and As using light spectrometry of an arseno-molybdate complex. The laboratory participated in an IAEA intercomparison exercise.

Year: 1986 - 1987
Country: Australia

Source: 112

Species: *Saccostrea cucullata, Saccostrea echinata*
Number of sites: 7
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Fe), Ni, Cu, Zn, Cd, Pb

Peerzada, N., and C. Dickson (1988) Heavy metal concentration in oysters from Darwin Harbour. Mar. Pollut. Bull., 19(4):182-4.
Oyster samples were collected within Darwin Harbour, Australia and analyzed for trace elements. Composite samples were digested with HNO_3 and the digestates analyzed using flame AAS. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the study. Sediment data is available. Results reported on a wet weight basis.

Year: 1986 - 1987
Country: Hong Kong

Source: 597

Species: *Perna viridis*
Number of sites: 14
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), (Fe), Cu, Zn, Cd, Pb

Chan, H. M. (1988) A survey of trace metals in *Perna viridis* (L.) (Bivalvia: Mytilacea) from the coastal waters of Hong Kong. Asian Mar. Biol., 5:89-102.
The concentrations of six elements were determined in mussels collected in Hong Kong from 1986 to 1987. Zinc levels fluctuated over a narrow range suggesting that *P. viridis* can regulate its Zn body level. The specimens were frozen, thawed, homogenized, and digested using HNO_3. The digestates were analyzed using AAS. NIST SRM 1572 (Citrus Leaves) and IAEA MA-A-3/TM (Shrimp Homogenate) were analyzed as part of the QA protocol.

Year: 1987
Country: Australia

Source: 4

Species: *Saccostrea cucullata, Saccostrea echinata*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Al), (Mn), (Fe), Ni, Cu, Zn, Cd, Pb

Peerzada, N., L. McMorrow, S. Skiliros, M. Guinea, and P. Ryan (1990) Distribution of heavy metals in Gove Harbour, Northern Territory, Australia. Sci. Total Environ., 92(-):1-12.
The concentrations of four metals in waters and eight metals in oysters and sediments from Gove Harbour, Northern Territory, were determined during the dry season of 1987. The Harbour lies in Melville Bay, and there a large bauxite mining company facility on its shores. The area is substantially a protected refuge, with two wharves, a bulk cargo wharf, and a general cargo wharf. Oyster specimens were digested using HNO_3 and the digests were analyzed using flame AAS. NIST SRM 1566 (Oyster Tissue) and SRM 1577 (Bovine Liver) were analyzed as part of the study. Sediment and seawater were also collected as part of this study. Data mean and/or range reported on a wet weight basis.

Year: 1987
Country: Mexico

Source: 31

Species: *Crassostrea corteziensis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Ag, Cd, Pb

Osuna Lopez, J. I., H. M. Zazueta-Padilla, A. Rodriguez Higuera, and F. Páez Osuna (1990) Trace metal concentrations in mangrove oyster (*Crassostrea corteziensis*) from tropical lagoon environments, Mexico. Mar. Pollut. Bull., 21(10):486-88.
This study reported preliminary results concerning variability of trace metal concentration in the mangrove oyster C. *corteziensis*. On the Pacific coast and particularly in Mexico this mollusk is widely used for human consumption, and is consequently of commercial importance. This report emphasizes variability in the distribution of the bivalve within mangrove roots can be an important parameter which should be considered in the design of sampling programs. Bivalves were collected at four seasonal intervals between October 1987 and July 1988 in the Mazatlan harbour. Composite sample of 25 individuals were dried digested with concentrated HNO_3. The digestates were analyzed using flame AAS. Quality control of the analysis was assured by routine analysis of reference material IAEA MA-M-2/TM (Mussel homogenate).

Year: 1987
Country: New Zealand

Source: 862

Species: *Crassostrea gigas*
Number of sites: 10
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cr, Cu, Zn, As, Cd, Pb. DDTs. PCBs. Pesticides. PAHs. Phenols.

Auckland Regional Water Board (1988) Manukau Harbor Action Plan Shellfish Quality Survey. Tech. Pub. 53. Auckland Regional Water Board, Auckland, New Zealand.
This is one of a series of data reports about the Manukau Harbour Action Plan. See main text of this document for description of the project. Data on trace organic contaminant levels is also included in this report. Data mean and/or range reported on a wet weight basis.

Year: 1987
Country: United States

Source: 365

Species: *Crassostrea virginica*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Zn

Mo, C., and B. Neilson (1991) Variability in measurements of zinc in *C. virginica*. Mar. Pollut. Bull., 22(10):522-5.
The purpose of this present study is to examine and quantify several sources of what might be called 'extraneous variability', so that underlying physiological relationships and cause-and-effect mechanisms can be elucidated. Specimens were collected from the James River, the Rappahannock River, and the Piankatank River, Virginia tributaries of the Chesapeake Bay. Tissues were digested with HNO_3 and the digestate analyzed using flame AAS.

Year: 1987 - 1988
Country: New Zealand

Source: 858

Species: *Crassostrea gigas*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Sn, Pb. DDTs. PCBs. Pesticides.

Auckland Regional Water Board (1988) Tamaki Estuary water quality survey. Tech. Pub. 54, Auckland Regional Water Board, Auckland, New Zealand, 16 pp.
This is one of a series of data reports about the Tamaki Estuary water quality survey. See main text of this document for description of the project. Data on trace organic contaminant levels is also included in this report.

Year: 1988?
Country: Australia

Source: 52

Species: *Mytilus edulis*, *Pinctada carcha-riarium*, *Saccostrea commercialis*, *Stavelia horrida*
Number of sites: 29
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd

McConchie, D. M., A. W. Mann, M. J. Lintern, D. Longman, V. Talbot, A. J. Gabelish, and M. J. Gabelish (1988) Heavy metals in marine biota, sediments and waters from the Shark Bay area, Western Australia. J. Coastal Res., 4(1):37-58.
Shark Bay is remote from all known sources of industrial and geological sources of heavy metals, yet some molluscs from the area showed high Cd concentrations that exceeded the limits for human consumption. Samples of sediment, water, and biota were collected at each sampling site. Samples were digested within hours of collection using HNO_3 and H_2O_2. The digestates were analyzed in the field for Cd, Cu, and Pb using ASV after further treatment with NaCl and ascorbic acid. The digestates were then analyzed in the laboratory for Cu and Zn using AAS. Results reported on a wet weight basis.

Year: 1988
Country: Bermuda

Source: 338

Species: *Arca zebra*
Number of sites: 7
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Leavitt, D. F., B. A. Lancaster, A. S. Lancaster, and J. M. Capuzzo (1990) Changes in the biochemical composition of a subtropical bivalve, *Arca zebra*, in response to contaminant gradients in Bermuda. J. Exp. Mar. Biol. Ecol., 138:85-98. [Trace metal data in this paper can also be found in Burns, K. A., M. G. Ehrhardt, J. MacPherson, J. A. Tierney, G. Kananen, and D. Connelly (1990) Organic and trace metal contaminants in sediments, seawater and organisms from two Bermudan harbours, J. Exp. Mar. Biol. Ecol., 138:9-34, and Widdows, J., K. A. Burns, N. R. Menon, D. S. Pageand S. Soria (1990) Measurement of physiological energetics (scope for growth) and chemical contaminants in mussels (*Arca zebra*) transplanted along a contamination gradient in Bermuda, J. Exp. Mar. Biol. Ecol., 138:99-117.]
The biochemical composition of *Arca zebra* specimens collected in Castle Harbour and Hamilton Harbour was studied. The specimens of turkey wing mussel were collected in Harrington Sound and deployed at the two sites. Sediment and seawater were also analyzed as part of this study.

Year: 1988
Country: Canada

Source: 460

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Li), (B), (Na), (Mg), (Al), (K), (Ca), (V), (Mn), Cu, Zn, As, Se, (Rb), (Sr), (Y), (Mo), Ag, Cd, (Cs), (Ba), (La), (Ce), Pb, (U)

Lobel, P. B., S. P. Belkhode, S. E. Jackson, and H. P. Longerich (1989) A universal method for quantifying and comparing the residual variability of element concentrations in biological tissues using elements in the mussel *Mytilus edulis* as a model. Mar. Biol., 102(4):513-18.
Mussel samples were collected in Bellevue, Newfoundland, and depurated. All mussels used were of the same size and were collected at the same time. The tissues were digested using HNO_3 and H_2O_2, and the resulting solutions analyzed using ICP-MS.

Year: 1988
Country: India

Source: 367

Species: *Crassostrea cucullata*
Number of sites: 2
Analytical methodology?: In cited paper
Quality assurance?: Yes
Analytes: (Mn), (Fe), Cu, Zn, Pb

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Mitra, A., and A. Choudhury (1993) Trace metals in macrobenthic molluscs of the Hooghly estuary, India. Mar. Pollut. Bull., 26(9):521-2.
Six macrobenthic organisms were collected from hard substrates at the confluence of the Hooghly river and the Bay of Bengal during the premonsoon and monsoon seasons. This is an area of intense human activity including several types of industries. More than 15 specimens of each species were collected, depurated and composited. The composite samples were dissolved using HNO_3 and the subsequent solutions analyzed using flame AAS. The NIES Sargasso Seaweed reference material was used as part of the quality assurance effort.

Year: 1988?
Country: Japan

Source: 649

Species: Mussels and oysters
Number of sites: 10
Analytical methodology?: NA
Quality assurance?: NA
Analytes: Cr, (Mn), Cu, Zn, Cd, Pb

Ikuta, K., (1988) Inherent differences in some heavy metal contents among Ostreids, Mytilids and Acmaeids. Nippon Suisan Gakkaishi, 54(5):811-6.
Multiple discriminant and discriminant analyses were applied to distinguish inherent differences for heavy metal contents among oysters, mussels, and limpets.

Year: 1988?
Country: Japan
Source: 648

Species: *Crassostrea gigas*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Cd

Ikuta, K., and A. Morikawa (1988) Distribution of heavy metals in soft bodies and shell cavity fluids of Crassostrea gigas. Nippon Suisan Gakkaishi, 54(10):1811-6.
The content of major and trace elements in the soft bodies and shell cavity fluids of oysters kept in ice boxes were determined over a period of time. At the same time, the N content of shell cavity fluids was also determined. Correlations between metal and nitrogen contents and serial times was not significant. The contents fluctuated independently without regard to elapsed time. The tissues were digested using HNO_3 and $HClO_4$ and the subsequent digestate analyzed using AAS.

Year: 1988
Country: Mexico
Source: 368

Species: *Crassostrea virginica*
Number of sites: 4
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), (Fe), Cu, Zn, Cd, Pb

Vazquez, G. F., G. M. Sanchez, an K. S. Virender (1993) Trace metals in the oyster *Crassostrea virginica* of the Terminos Lagoon, Campeche, Mexico. Mar. Pollut. Bull., 27(7):398-9.
Specimens of *Crassostrea virginica* were collected over seven months at four stations in the Terminos Lagoon, in the Yucatan Peninsula. Composite samples were analyzed by dissolution using HNO_3 and HCl and subsequent metal determination using graphite furnace AAS.

Year: 1988
Country: New Zealand
Source: 866

Species: *Perna canaliculus*
Number of sites: 6
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: (Fe), Cr, Ni, Cu, Zn, Cd

Taranaki Catchment Board (1989) Water Right Impact Monitoring. North Taranaki District Council Marine Outfall Trace Metals Monitoring Programme. Tech. Rep. 89-7 (ISSN 0112-0425), Taranaki Catchment Commission, Stratford, New Zealand, 83 pp.
Mussels were chilled after collection and allowed to depurate. The specimens were then shucked, drained and frozen. The analytical methodology used is based on that FAO using AAS. The tissues were digested using HNO_3 and H_2O_2. Data mean and/or range reported on a wet weight basis.

Year: 1988
Country: United States

Source: 127

Species: *Crassostrea virginica*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Al), (V), Cr, (Mn), (Fe), Co, Ni, Cu, Zn, (Mo), Ag, Cd, Hg, Pb

Lytle, T. F., and J. S. Lytle (1990) Heavy metals in the eastern oyster, *Crassostrea virginica*, of the Mississippi Sound. Bull. Environ. Contam. Toxicol., 44(1):142-8.
Levels of metals in oysters in the Mississippi Sound are of profound interest not only because they document those geographic areas where metal pollution levels may be problematic but because they may disclose possible problems to consumers of oysters. Analyses were made of individual specimens to indicate expected specimen to specimen variations. All tissue and liquid was removed, weighed, and included for analyses. For all metals but Hg, tissue was digested with HNO_3, H_2SO_4, and H_2O_2. These digests and appropriate reagent blanks were diluted to volume and analyzed using flame AAS. Mercury was measured by digestion of a separate set of samples digested with H_2SO_4 and HNO_3. After reduction with $SnCl_2$, Hg vapor was flushed through a quartz cell in the AAS. Results reported on a wet weight basis.

Year: 1988 - 1989
Country: New Zealand

Source: 863

Species: *Crassostrea gigas*
Number of sites: 12
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cr, Cu, Zn, As, Cd, Pb. DDTs. PCBs. Pesticides. PAHs.

Auckland Regional Water Board (1990) Shellfish Quality Survey 1988 and 1989. Tech. Pub. 86. Auckland Regional Water Board, Auckland, New Zealand, 78 pp.
This is one of a series of data reports about the Manukau Harbour Action Plan. See main text of this document for description of the project. Data on trace organic contaminant levels is also included in this report.

Year: 1989
Country: Egypt

Source: 118

Species: *Mytilus minimus*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Se, Pb

Abdel-Moati, A., and M. M. Atta (1991) *Patella vulgata*, *Mytilus minimus* and *Hyale prevosti* as bioindicators for Pb and Se enrichment in Alexandria coastal waters. Mar. Pollut. Bull., 22(3):148-10.
Mytilus minimus specimens were collected from intertidal sites off the Alexandria coast, Egypt. Sampling and storage was in accordance with UNEP/FAO/IAEA/IOC guidelines. Tissue composites were digested using HNO_3 and the digestates were analyzed using graphite furnace AAS for Pb and hydride generation AAS for Se. NIST SRM 1566 (Oyster Tissue) and SRM 1571 (Orchard Leaves) were analyzed as part of the study.

Year: 1989 - 1990
Country: Mexico

Source: 542

Species: *Crassostrea iridescens*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Mn), (Fe), Ni, Cu, Zn, Cd

Páez-Osuna, F., M. G. Frías-Espericueta, and J. I. Osuna-López (1995) Trace metal concentrations in relation to season and gonadal maturation in the oyster *Crassostrea iridescens*. Mar. Environ. Res., 40(1):19-31.
The gonadal development and the concentrations of six trace metals associated with gonadal and somatic tissue throughout the reproductive cycle of the oyster *Crassostrea iridescens* have been studied. Specimens were collected from a single population at one site during a season and the concentrations of the metals determined in gonadal, somatic, and whole tissue. Tissues were digested in concentrated quartz-distilled HNO_3. The digestate was evaporated to dryness and then dissolved in HNO_3. IAEA MA-M-2/TM (Mussel Homogenate) reference material was used as part of the QA protocol.

Year: 1990
Country: Ireland

Source: 361

Species: *Mytilus edulis*
Number of sites: 12
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Ag, Cd, Hg, Pb

Berrow, S. D. (1991) Heavy metals in sediments and shellfish from Cork Harbour, Ireland. Mar. Pollut. Bull., 22(9):467-9.
Thirteen sites in Cork Harbour were visited in 1990. All sites were intertidal, except for two which were sublittoral and were sampled using an Ekman grab. At each site, three samples of sediment and mussels were removed. After depuration, composite mussel samples were prepared using a minimum of five mussels collected at the mid-tide level at each site. The tissue samples were digested with HNO_3 and H_2O_2. NRC CRM MESS-1 (Marine Sediment) was analyzed as part of the study.

Year: 1990
Country: Korea

Source: 924

Species: *Mytilus edulis, Mytilus coruscus*
Number of sites: 16
Analytical methodology?: Paper in Korean
Quality assurance?: Paper in Korean
Analytes: (Al), (Ti), Cr, (Mn), (Fe), Ni, Cu, Zn, As, (Sr), (Mo) Cd, Hg, Pb

Korea Ocean Research and Development Institute (1990) A study on the coastal water pollution and monitoring - third year. BSPG 00112-315-4, Korea Ocean Research and Development Inst., Seoul, Korea, 261 pp.
[Paper in Korean.] Mussels were collected from 19 sites along the Korean coast line as part of the Mussel Watch Project of Korea. Other species were also collected and analyzed.

Year: 1990?
Country: Mexico
Source: 362

Species: *Crassostrea corteziensis*
Number of sites: 10
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Cd, Pb

Páez-Osuna, F., H. M. Zazueta-Padilla, and G. Izaguirre-Fierro (1991) Trace metals in bivalves from Navachiste, Mexico. Mar. Pollut. Bull., 22(6):305-7.
Crassostrea corteziensis specimens were collected from the Navachiste Lagoon before the spawning period in March. Composite oyster samples were digested using HNO_3 and the digestates were analyzed using flame AAS. IAEA reference material MA-M-2/TM (Mussel Homogenate) was analyzed as part of the study.

Year: 1990
Country: New Zealand
Source: 857

Species: *Crassostrea gigas*
Number of sites: 11
Analytical methodology?: In cited paper
Quality assurance?: NA
Analytes: Cr, Cu, Zn, As, Cd, Pb. DDTs. PCBs. Pesticides. PAHs. Phenols.

Auckland Regional Water Board (1992) Manukau Harbour shellfish quality survey 1990. Tech. Pub. 1, Auckland Regional Council, Auckland, New Zealand, 43 pp.
This is one of a series of data reports about the Manukau Harbour Action Plan. See main text of this document for description of the project. Data on trace organic contaminant levels is also included in this report.

Year: 1990 - 1991
Country: Morocco
Source: 815

Species: *Mytilus edulis*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cd, Hg, Pb

El Hraiki, A., A. Alaout, and D. R. Buhler (1994) The use of mussels to determine the extent of trace metal contamination along Moroccan Atlantic coast. Toxicol. Environ. Chem., 41:31-7.
Mussels were collected along the Moroccan coast to evaluate trace metal contamination. The results of show high levels for Cd and Pb, but were relatively high for Hg. The Hg levels, however, were lower than the maximum permissible levels for human consumption set by Mediterranean countries. Composite tissue samples were digested using HNO_3. The resulting digestates were analyzed using GFAAS for Cd and Pb and for Hg using CVAAS. UNEP/FAO/IAEA/IOC methods were followed. IAEA MA-B-3/TM was used as part of the QA protocol. Data mean and/or range reported on a wet weight basis.

Year: 1991
Country: Canada

Source: 412

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mg), (Mn), (Fe), Cu, Zn, As, Se, Ag, Cd, Pb

Chou, C. L., and J. F. Uthe (1991) Effect of starvation on trace metal levels in blue mussels (*Mytilus edulis*). Bull. Environ. Contam. Toxicol., 46:473-8.
Mussels were collected during the autumn neat Petit Rocher, New Brunswick, Canada, approximately 10 km from a lead smelter. The animals were transported live and held in an aquarium to determine the effect of starvation on trace metal levels. Tissue were refluxed with HNO_3 and the resulting solutions analyzed using AAS. Only concentrations of mussels analyzed immediately after collection are listed in the database. Results reported on a wet weight basis.

Year: 1991?
Country: Japan

Source: 647

Species: *Crassostrea gigas*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), Ni, Cu, Zn, As, Cd, Pb

Hiraoka, Y. (1991) Reduction of heavy metal content in Hiroshima Bay oysters (Crassostrea gigas) by purification. Environ. Pollut., 70:209-17.
Cultured oysters from Hiroshima Bay were analyzed to determine the content of major and trace elements and compared with oysters treated for 48 hrs in both artificial seawater and a solution of ethylenediaminetetracetic acid (EDTA) in artificial seawater. It was found that the levels of As and Fe in the treated oysters was lower. Oysters were shucked, drained, and weighed. The tissues were digested using HNO_3 and H_2SO_4 and the subsequent digestates analyzed using a sequential plasma spectrometer.

Year: 1991
Country: Spain

Source: 749

Species: *Mytilus galloprovincialis*
Number of sites: 6
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Fe), Ni, Cu, Zn, Cd, Pb

Soto, M., M. Kortabitarte, and I. Marigómez (1995) Bioavailable heavy metals in estuarine waters as assessed by metal/shell-weight indices in sentinel mussels *Mytilus galloprovincialis*. Mar. Ecol. Prog. Ser., 125(-):127-36.
Seasonal variations in metal concentrations in soft tissues of mussels collected in the Bay of Biscay, Spain, were studied. The Abra Estuary in the Bay of Biscay has well-known differences in levels of metallic pollutants. The level of metal bioavailability was determined at various sites in the estuary. Seasonal changes in organism condition were found to cause unpredictable oscillations in the metal concentrations of soft tissues. Mussels were collected, allowed to depurate, and dissected. The soft tissues were rinsed in distilled water, dried, and pooled. The pooled samples were digested in HNO_3 and the subsequent digestates analyzed using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1991 - 1992
Country: Bahrain

Source: 463

Species: *Pinctada radiata*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), Ni, Cu, Zn, Cd, Pb

Al-Sayed, H. A., A. M. Mahasneh, and J. Al-Saad (1994) Variations of trace metal concentrations in seawater and pearl oyster *Pinctada radiata* from Bahrain (Arabian Gulf). Mar. Pollut. Bull., 28(6):370-4.
Oysters and seawater were collected at two sites in Bahrain and analyzed for trace metals. The oysters were shucked, dried, and ground. The dried tissues were digested using HNO_3 and $HClO_4$ and the digestates analyzed using AAS. Data mean and/or range reported on a dry weight basis.

Year: 1991 - 1992
Country: Chile

Source: 826

Species: *Choromytilus chorus*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Cd, Hg, Pb

Ahumada, B. (1994) Nivel de concentracion e indice de bioacumulacion para metales pesados (Cd, Cr, Hg, Ni, Cu, Pb, y Zn) en tejidos de invertebrados nemticos de Bahia San Vicente, Chile. Rev. Biol. Mar., Valparaiso, 29(1):77-87.
San Vicente Bay, Chile, is an industrialized embayment. Benthic invertebrates were collected and analyzed for trace metals to determine level of contamination and the bioaccumulation index. Specimens of the mussel *Choromytilus chorus* were immediately frozen after collection. The tissues were then thawed, lyophilized, and homogenized. The samples were digested using HNO_3 and $HClO_4$ and the subsequent solutions analyzed using AAS and GFAAS. IAEA SD-N-1/2 TM (Marine Sediment) and NRC DORM-1 (Dogfish Muscle) were analyzed as part of the QA protocol. Other sampling sites were sampled for seawater and sediment.

Year: 1992
Country: Chile

Source: 724

Species: *Mytilus edulis*
Number of sites: 9
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Cd

Manly, R., S. P. Blundell, F. W. Fifield, and P. J. McCabe (1996) Trace metal concentrations in *Mytilus edulis* L. from the Laguna San Rafael, southern Chile. Mar. Pollut. Bull., 32(5):444-8.
Samples of *Mytilus edulis* were collected from the Laguna San Rafael National Park, Chile, and analyzed for trace metals. The specimens were allowed to depurate, frozen, thawed, shucked, and dried. The dried tissues were digested in HNO_3 and H_2O_2. The resulting digestate was analyzed using ICP. NIST SRM 1566a (Oyster Tissue) was analyzed as part of the QA protocol.

Year: 1992
Country: Italy

Source: 808

Species: *Mytilus galloprovincialis*
Number of sites: 1
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (Al), Cr, (Mn), (Fe), (Co), Ni, Cu, Zn, Cd, Hg, Pb

Fagioli, F., C. Locatelli, and S. Landi (1994) Heavy metals in the Goro Bay: sea water, sediments and mussels. Annali di Chimica, 84(3-4):129-40.
Mussels were collected from a mussel farm in Goro Bay. Some were allowed to depurate and some were not. The two types of mussel samples were washed, shucked, homogenized, lyophilized, powdered, and dried. The tissue samples were digested using HNO_3 and either H_2SO_4 or $HClO_4$. The resulting solutions were analyzed using AAS and GFAAS. Aliquots of tissue samples were digested using H_2SO_4 and K_2CrO_7. NIST SRM 1566 (Oyster Tissue) was analyzed as part of this study. Seawater and sediment samples were also collected and analyzed.

Year: 1992
Country: Kuwait

Source: 551

Species: *Pinctada radiata*
Number of sites: 3
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Ni, Cu, Cd, Pb

Bou-Olayan, A-H., S. Al-Mattar, A. Al-Yakoob and S. Al-Hazeem (1995) Accumulation of lead, cadmium, copper and nickel by pearl oyster *Pinctada radiata*, from Kuwait marine environment. Mar. Pollut. Bull., 22(6):305-7.
Specimens of *Pinctada radiata* were collected in Kuwait in 1990 and 1992. Only the 1992 is available in the cited paper. Composite samples of 15 oysters were defrosted, shucked, drained, removed from the shells, and weighed. The specimens were frozen upon collection. Prior to analysis, the oysters were defrosted, shucked, drained, and composited. The tissues were digested using HNO_3 and subsequently analyzed using AAS. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the QA protocol.

Year: 1992?
Country: Spain

Source: 818

Species: *Crassostrea angulata*
Number of sites: 7
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Cu, As, Cd, Hg, Pb

Schuhmacher, M., and J. L. Domingo (1996) Concentrations of selected elements in oysters (*Crassostrea angulata*) from the Spanish coast. Bull. Environ. Contam. Toxicol., 56(-):106-13.
Spanish coastal waters are biologically productive and physically diverse marine ecosystems with important commercial fishing and shellfish industries. A large number of the rivers that flow into these coastal areas are subjected to large loads of toxic industrial residues. To document levels of trace elements in shellfish along the Spanish coast, specimens of *Crassostrea angulata* were purchased in various coastal cities and analyzed. The samples were kept frozen until analyzed. The specimens were then shucked, composited, homogenized, and dried. The homogenized tissue was digested using HNO_3 and $HClO_4$. The subsequent solutions were analyzed fro HG using CVAAS after reduction using $SnCl_2$. Lead and As were analyzed using GFAAS. Cadmium, Cr, and Cu were analyzed using ICPMS. NIST SRM 1577a (Bovine Liver) was analyzed as part of this study.

Year: 1992 - 1993
Country: Australia

Source: 733

Species: *Mytilus edulis*
Number of sites: 1
Analytical methodology?: NA
Quality assurance?: Yes
Analytes: Cr, Cu, Zn, As, Cd, Hg. Other organic chemicals.

Haynes, D., and D. Toohey (1995) Temporal variation in polychlorinated dibenzo-*p*-dioxins, dibenzofurans, extractable organohalogens and heavy metals in commercially cultured mussels (*Mytilus edulis)* from Port Phillip Bay, Victoria, Australia. Mar. Pollut. Bull., 30(12):885-91.
This is a two-year study of the levels of polychlorinated dibenzo-*p*-dioxins, dibenzofurans, extractable organohalogens, and heavy metals in mussels in Port Phillip Bay. The specimens for trace metal analysis were shucked, composited, freeze dried, and digested using HNO_3 and $HClO_4$. The digestates were analyzed using AAS and CVAAS. BCR CRM 278 (Mussel Tissue) was analyzed as part of the QA protocol. Data mean and/or range reported on a dry weight basis.

Year: 1992 - 1993
Country: Chile

Source: 801

Species: *Perumytilus purpurus, Semelle solida, Tagellus dombeii*
Number of sites: 8
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd

De Gregori, I., H. Pinochet, N. Gras, and L. Muños (1996) Variability of cadmium, copper and zinc levels in molluscs and associated sediments from Chile. Environ. Pollut., 92(3):359-68.
The levels of Cu, Zn, and Cd in mussels from eight sites along the coast of Chile were determined. The metal levels in species collected in the same site varied. The mussel specimens were frozen immediately after collection. Pooled samples were freeze dried. Metal determination was carried out by NAA; Zn by an instrumental mode, Cd and Cu with radiochemical separations. NIST SRM 1566 (Oyster Tissue) and BCR CRM 1646 (*Mytilus edulis*) were analyzed as part of this study.

Year: 1992 - 1993
Country: Italy

Source: 848

Species: *Dreissena polymorpha*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, Ni, Cu, Zn, Cd, Hg, Pb

Carmusso, M., R. Balestrini, F. Muriano, and M. Mariani (1994) Use of freshwater mussel *Dreissena polymorpha* to assess trace metal pollution in the lower River Po (Italy). Chemosphere, 29(4):729-45.
This is a transplantation study of mussels to the River Po. Native zebra mussels were also collected and the results of the analysis of these specimens is listed in the database. The mussels were frozen, thawed, shucked, freeze dried, homogenized, and digested using HNO_3. The digestates were analyzed for Zn using AAS, for Cd, Cr, Cu, Ni, and Pb using GFAAS, and for Hg using CVAAS. BCR CRM 278 (Mussel Tissue) was analyzed as part of the QA protocol. Water was also collected and analyzed as part of this study.

Year: 1993
Country: United States

Source: 849

Species: *Crassostrea virginica*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: (V), (Fe), Ni, Cd, (Ba), Hg, Pb

Trefry, J. H., K. L. Naito, R. P. Trocine, and S. Metz (1995) Distribution and bioaccumulation of heavy metals from produced water discharges to the Gulf of Mexico. Wat. Sci. Tech., 32(2):31-6.

Produced water is found in sub-seafloor sedimentary formations from which oil and gas are derived. The water is separated from the oil or gas and discharged back into the well or to adjacent waters. Oysters were collected from the oil production platforms and frozen. Samples were analyzed using a variety of techniques depending upon type of sample and metal concentration. NRC CRMs NASS-2 (Seawater), TORT-1 (Lobster hepatopancreas) and BCSS-1 (Marine Sediment), and NIST SRM 1566 (Oyster Tissue) were analyzed as part of the QA protocol. Seawater, sediment, and other species of biota were also collected and analyzed as part of this study.

Year: 1993 - 1994
Country: New Zealand

Source: 846

Species: *Crassostrea gigas*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: (Mn), (Fe), Cu, Zn, Cd

Butler, C., and M. H. Timperley (1996) Fertilized farmland as a source of cadmium in oysters. Sci. Total Environ., 181(-):31-44.

Cadmium from phosphate fertilizers added to pasture soils in the Mahurangi catchment is mobile through leaching and erosion. This paper discusses the pathway of Cd in the estuarine system and oysters of Mahurangi Harbour. Oysters were digested using HNO_3 and H_2SO_4. The digestates were analyzed for Cu, Zn, Fe, and Mn using AAS and for Cd using GFAAS. Soils, sediments, and water were also collected and analyzed as part of this study. Results reported on a wet weight basis.

Year: 1994?
Country: Australia

Source: 756

Species: *Mytilus edulis planulatus*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, Cd, Hg, Pb

Richardson, B. J., J. S. Garnham, and J. G. Fabris (1994) Trace metal concentrations in mussels (*Mytilus edulis planulatus* L.) transplanted into southern Australian waters. Mar. Pollut. Bull., 28(6):392-6.

This is a transplantation study in which mussels were moved from a mussel farm in Port Phillip Bay to four other sites. The mussel samples were frozen without purging. Upon thawing, the mussels were shucked, freeze dried, and homogenized. The tissue samples were then digested using a UNEP/FAO/IAEA protocol and the digestates analyzed using AAS. Mercury was determined on subsamples of the freeze dried tissues by digestion with H_2SO_4 and HNO_3. Subsequent addition of MnO_4^- and $SnCl_2$ resulted in production of Hg^0 which was measured using CVAAS. NIST SRM 1566 (Oyster Tissue) was analyzed as part of the QA protocol. Water samples were also collected and analyzed as part of this study.

Year: 1995?
Country: Croatia
Source: 822

Species: *Mytilus galloprovincialis*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cu, Zn, As, Se, Sb, Hg

Vukadin, I., T. Zvonaric, and N. Odzak (1995) Fate and distribution of toxic heavy metals in some marine organisms from the eastern Adriatic coast. Helgoländer Meeresunters, 49():679-88.

Levels of heavy metals in various organisms from the eastern Adriatic coast and polluted areas near Split were determined. High levels of Hg and methylmercury in sea bream and stripped mullet were attributed to geochemical anomalies. High levels of Hg and methyl mercury in the gills and hepatopancreas of bivalves were also found. Bacterial activity in the intestine of the animals studies may be responsible for methylation. Methods used were those of UNEP/FAO/IAEA/IOC. Samples were digested in HNO_3. Total Hg and methyl mercury were determined using NAA and CVAAS. The other elements were determined using AAS. NIST SRM 1566 (Oyster Tissue), SRM 1572 (Orchard Leaves), and SRM 1577a (Bovine Liver) were analyzed as part of the QA protocol. Results reported on a wet weight basis.

Year: 1995?
Country: United States
Source: 747

Species: *Mytilus edulis, Modiolus demissus*
Number of sites: 2
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cr, (Mn), (Fe), Ni, Cu, Zn, Cd, Pb

Nelson, W. G., B. J. Bergen, and D. J. Cobb (1995) Comparison of PCB and trace metal bioaccumulation in the blue mussel, *Mytilus edulis*, and the ribbed mussel, *Modiolus demissus*, in New Bedford, Massachusetts. Environ. Toxicol. Chem., 14(3):513-21.

This is a transplantation study in which mussels from a clean site in East Sandwich, MA, were transplanted to New Bedford Harbor, an area heavily impacted. Only initial condition metal values were added to the database. The mussels were pooled and a portion of this homogenate was freeze dried. The tissue samples were digested using HNO_3 and H_2O_2, and the subsequent solutions analyzed using ICP.

Year: 1996?
Country: Greece
Source: 823

Species: *Mytilus galloprovincialis*
Number of sites: 5
Analytical methodology?: Yes
Quality assurance?: NA
Analytes: Cu, Zn, Cd, Pb

Antoniu, V., N. Zantopoulos, and S. Tsitsamis (1996) Heavy metal concentrations in mussels from the Gulf of Olympias - Chalkidiki, Greece. J. Environ. Sci. Health, A31(1):55-65.

The levels of Cu, Zn, Cd and Pb in mussels collected from the Gulf of Olympias and Makriyalos, Greece, were determined. The gulf receives sewage from the nearby metalliferous areas sulfur mines. Makrilyalos, an open sea area of the Thermaikos Gulf, is a mussel culture area. The samples were digested in HNO_3 and $HClO_4$. Copper and Zn were determined using AAS. The digestates were treated with ammonium pyrrolidine dithiocarbamate and extracted with MIBK. The resulting organic solution was analyzed for Pb and Cd using AAS. Results reported on a wet weight basis.

Year: 1996?
Country: Spain

Source: 845

Species: *Mytilus galloprovincialis*
Number of sites: 43
Analytical methodology?: Yes
Quality assurance?: Yes
Analytes: Cr, (Co), Ni, Cu, Zn, Pb

Puente, X., R. Villares, E. Carral, and A. Carballeira (1996) Nacreous shell of *Mytilus galloprovincialis* as a biomonitor of heavy metal pollution in Galiza (NW Spain). Sci. Total Environ., 183(-):205-211.

The shells of mussels collected along the coast of Galicia as well as the soft parts were used to evaluate heavy metal pollution. The tissues were digested using HNO_3 and the digestates analyzed using AAS. NIES CRM No. 6 (Mussel) and NRC MESS-1 (Marine Sediment) were analyzed as part of the QA protocol. Only mean and range concentrations are reported in the paper. Sediment samples were also collected and analyzed. Data mean and/or range reported on a dry weight basis.

APPENDIX II

Indices to WMW database Sources

II.1. Index by analyte and country

II.2. IIndex by author

APPENDIX III

World Mussel Watch Database Bibliography

Abdel-Moati, A., and M. M. Atta (1991) *Patella vulgata, Mytilus minimus* and *Hyale prevosti* as bioindicators for Pb and Se enrichment in Alexandria coastal waters. Mar. Pollut. Bull., 22(3):148-10.

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Antoniu, V., N. Zantopoulos, and S. Tsitsamis (1996) Heavy metal concentrations in mussels from the Gulf of Olympias - Chalkidiki, Greece. J. Environ. Sci. Health, A31(1):55-65.

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APPENDIX IV

World Mussel Watch Database Statistics and Graphics

IV.1. Single bivalve species

IV.1.1. Chromium

IV.1.1.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	345	728
Minimum	0	0
Maximum	440	320
Mean	6.3	5.4
Median	2	2
Standard deviation	32	14

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.1.1.2. Graphics

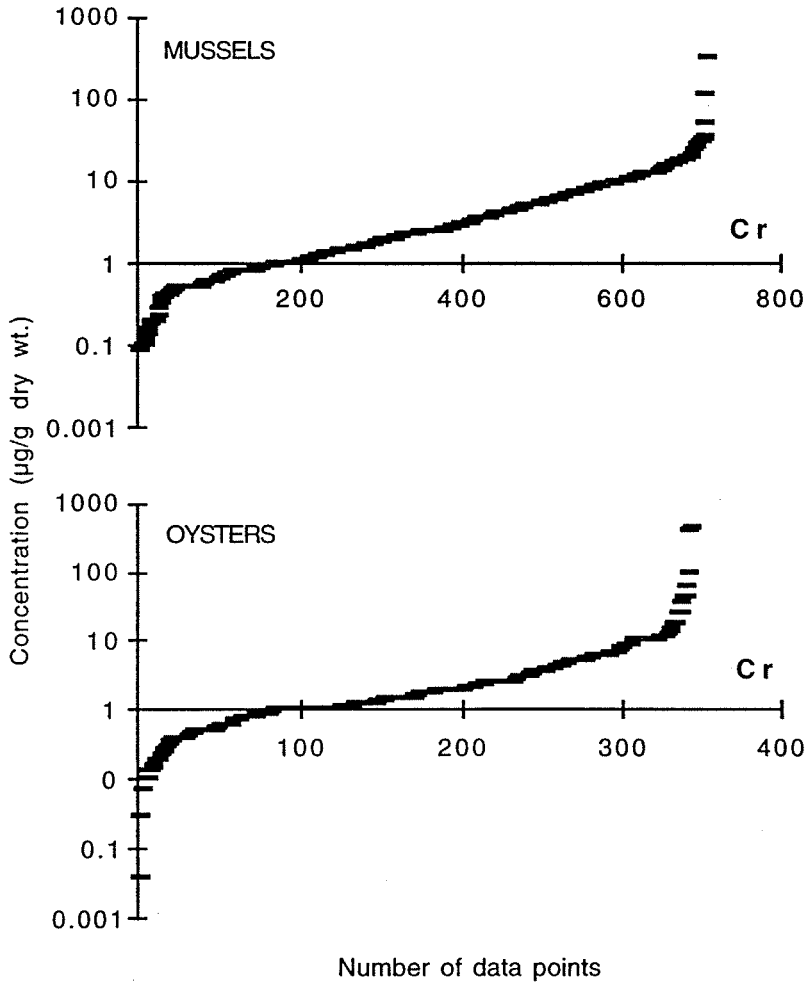

Figure IV.1. Chromium data in WMW database in increasing order (µg/g dry wt.).

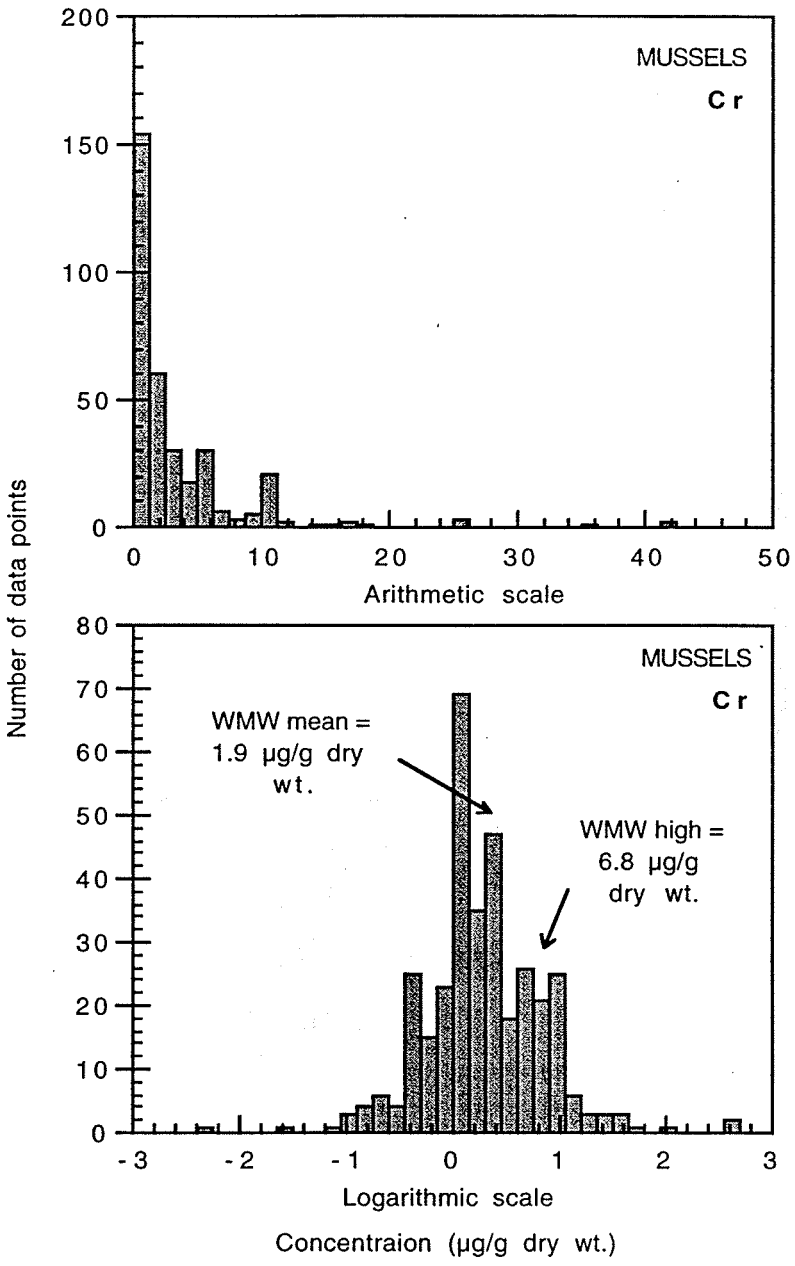

Figure IV.2. Distribution of chromium in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data was used in calculations. Some high concentrations not shown.)

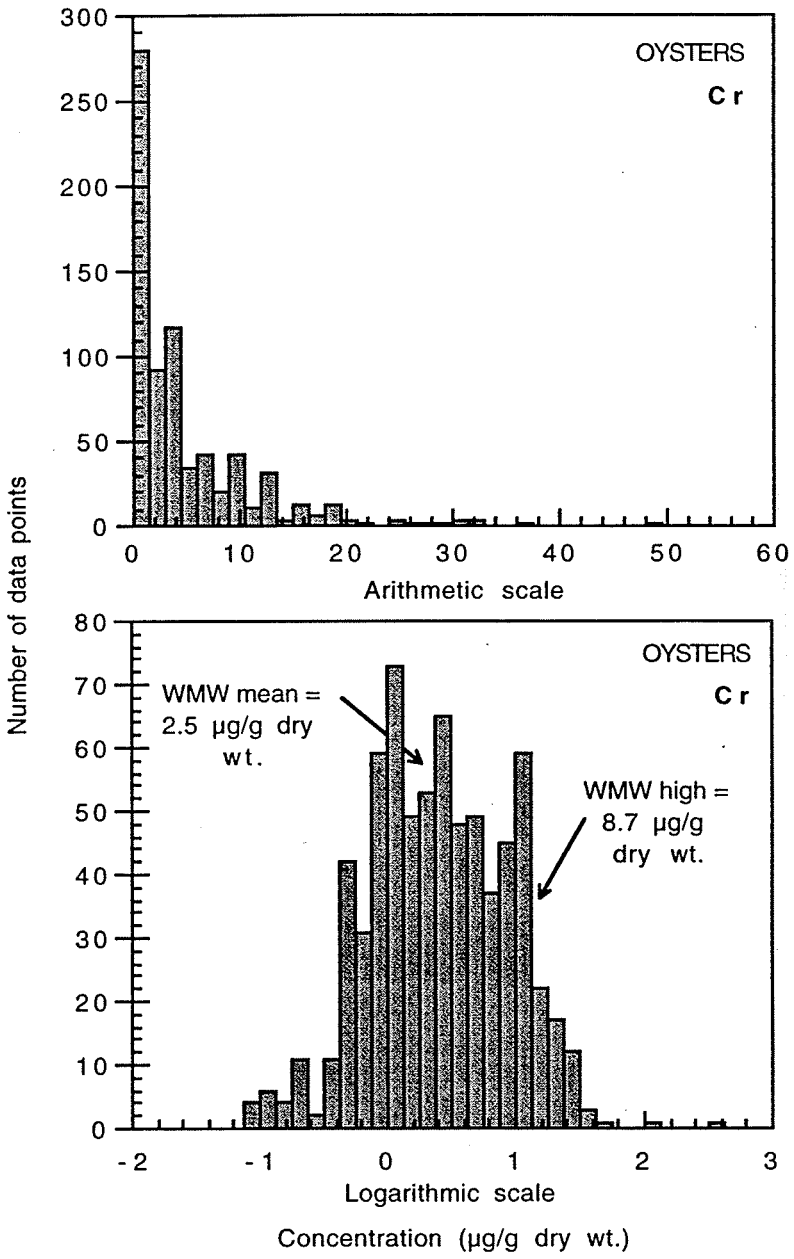

Figure IV.3. Distribution of chromium in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data was used in calculations. Some high concentrations not shown.)

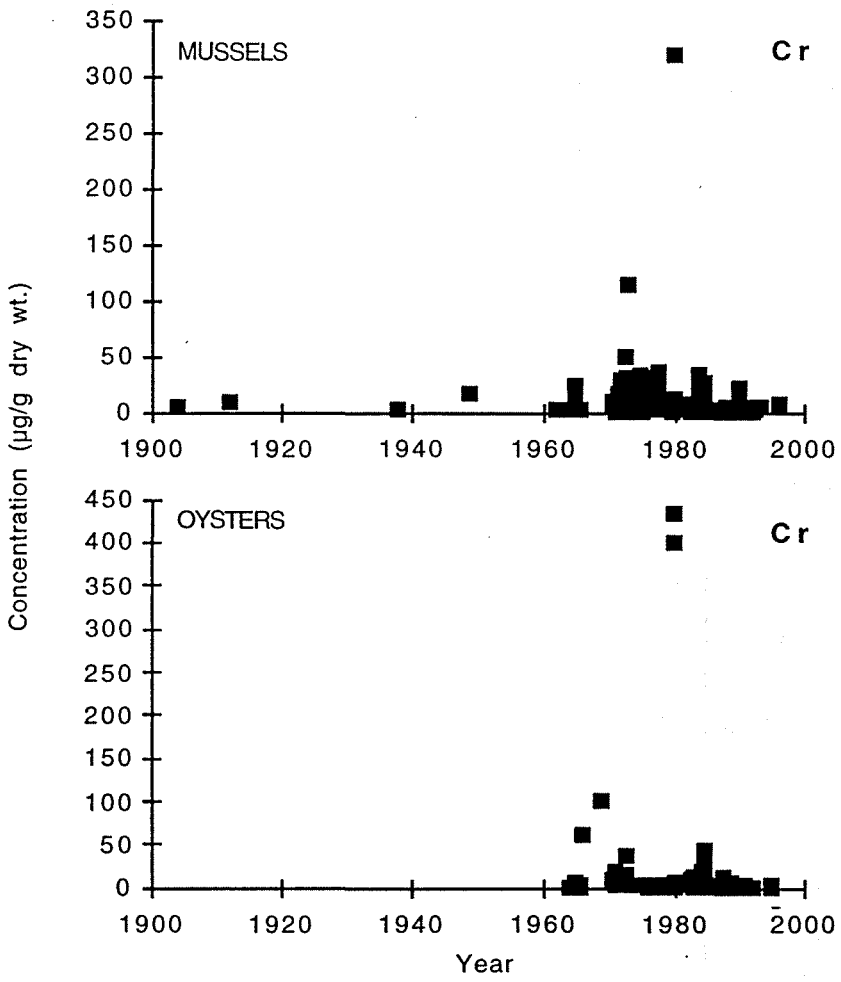

Figure IV.4. Chromium data in WMW database by year (µg/g dry wt.).

IV.1.2. Nickel

IV.1.2.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	783	320
Minimum	0	0
Maximum	2400	78
Mean	7.0	3.6
Median	2	2
Standard deviation	84	6.8

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.1.2.2. Graphics

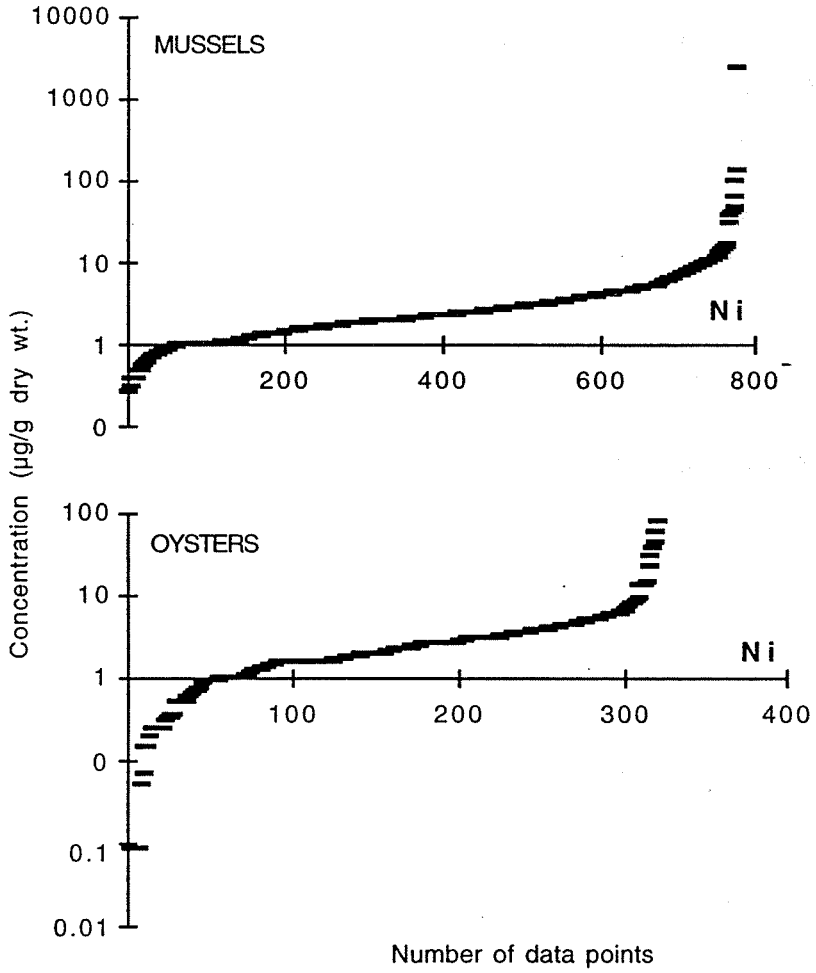

Figure IV.5. Nickel data in WMW database in increasing order (µg/g dry wt.).

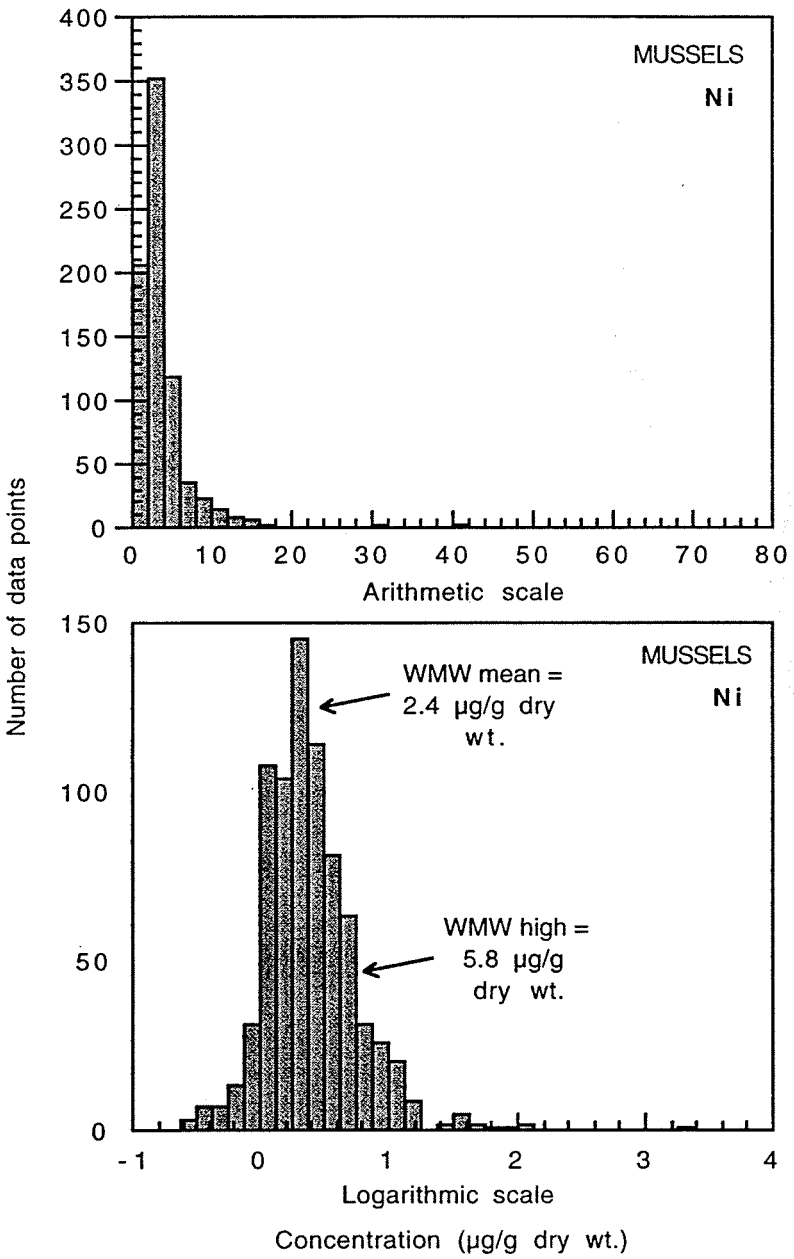

Figure IV.6. Distribution of nickel in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data was used in calculations. Some high concentrations not shown.)

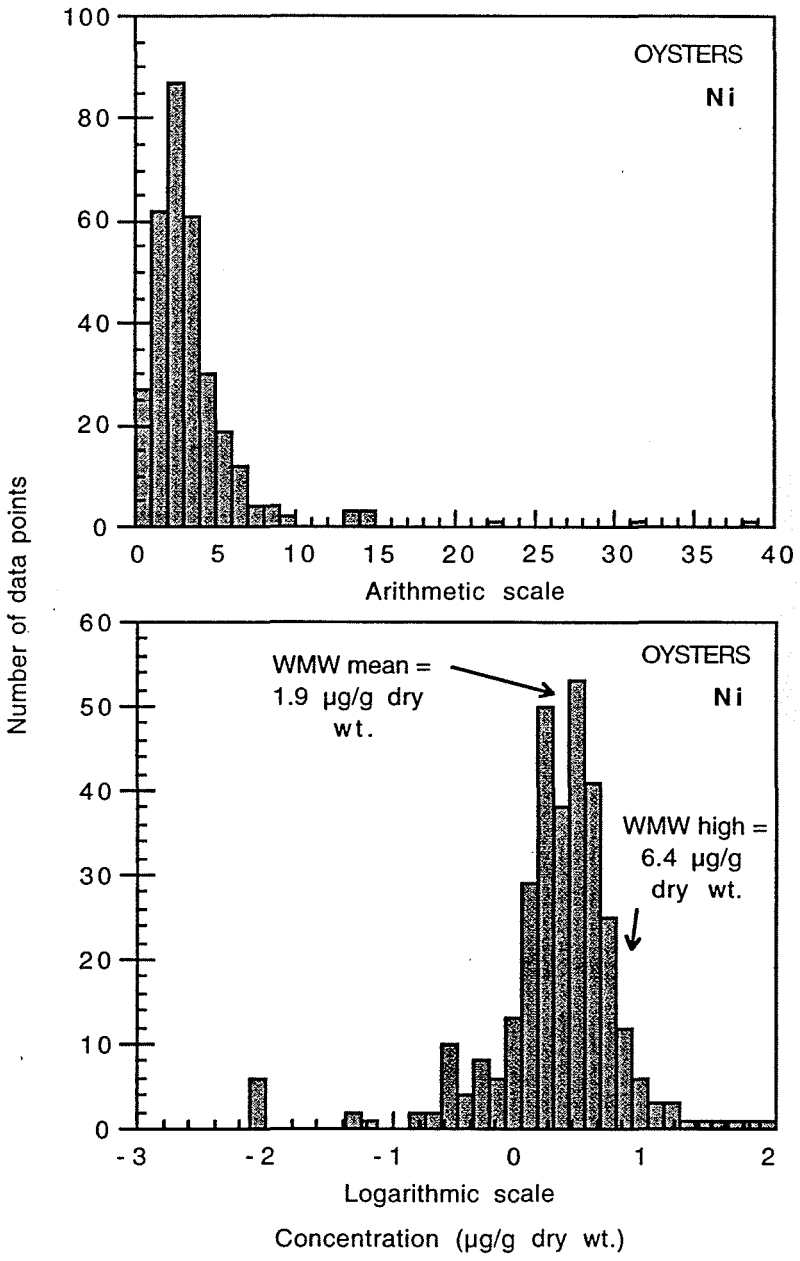

Figure IV.7. Distribution of nickel in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data was used in calculations. Some high concentrations not shown.)

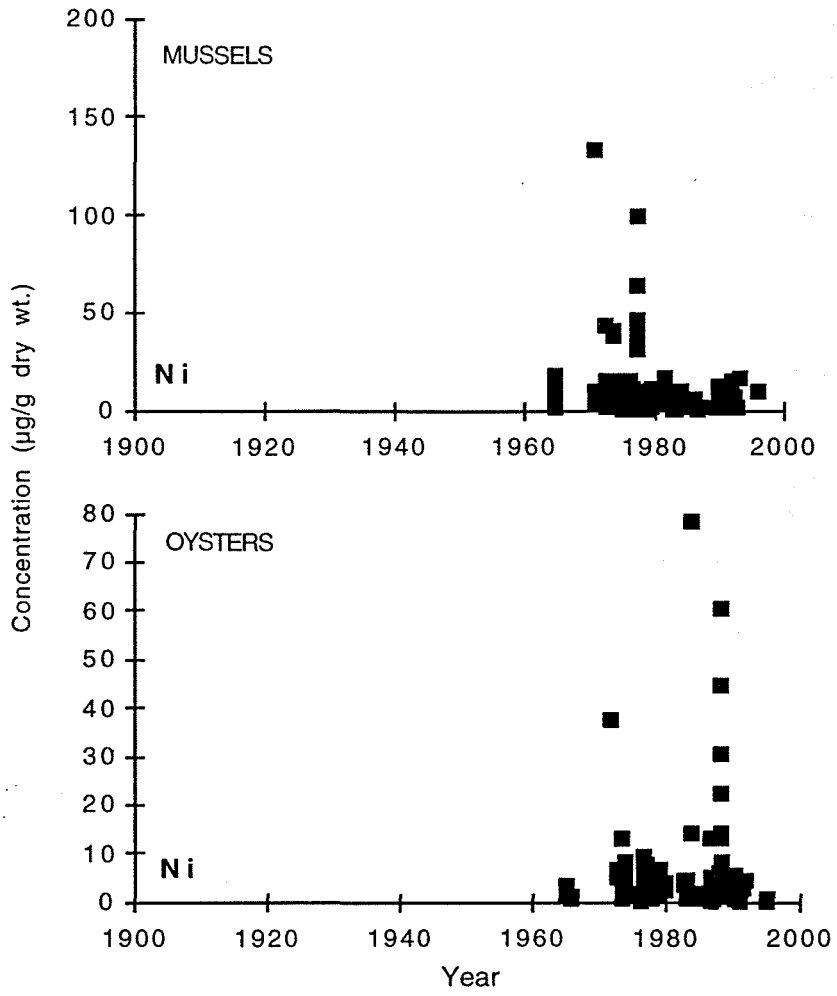

Figure IV.8. Nickel data in WMW database by year (µg/g dry wt.). (High value of 2300 µg/g dry wt. in mussels not shown.)

IV.1.3. Copper

IV.1.3.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	1888	1972
Minimum	0	0
Maximum	4300	14000
Mean	38	380
Median	8	160
Standard deviation	220	920

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.1.3.2. Graphics

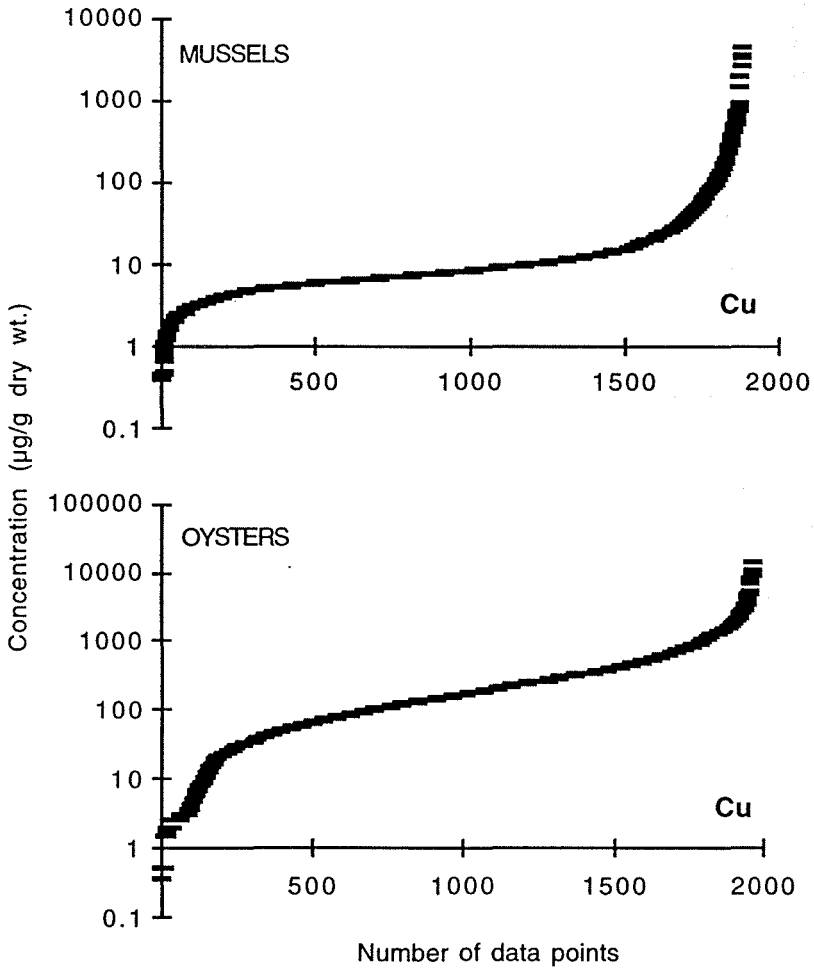

Figure IV.9. Copper data in WMW database in increasing order (µg/g dry wt.).

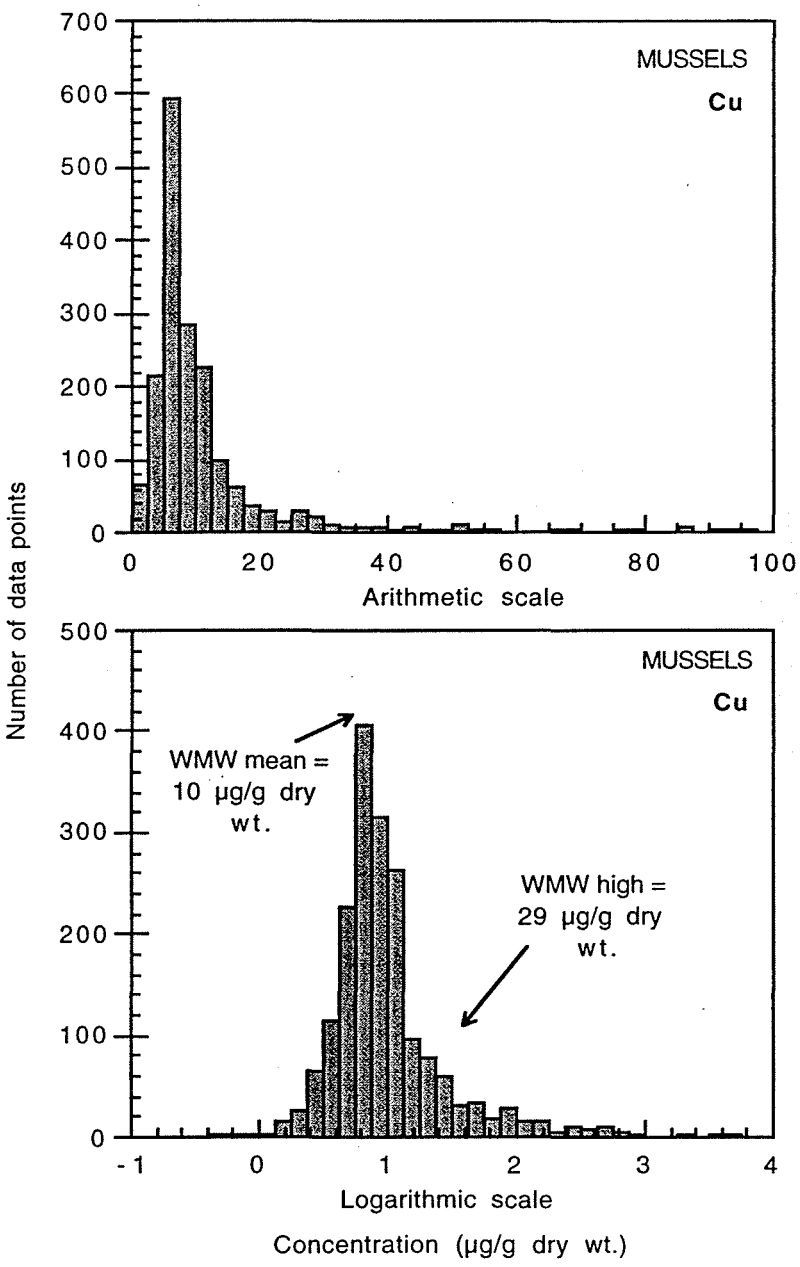

Figure IV.10. Distribution of copper in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

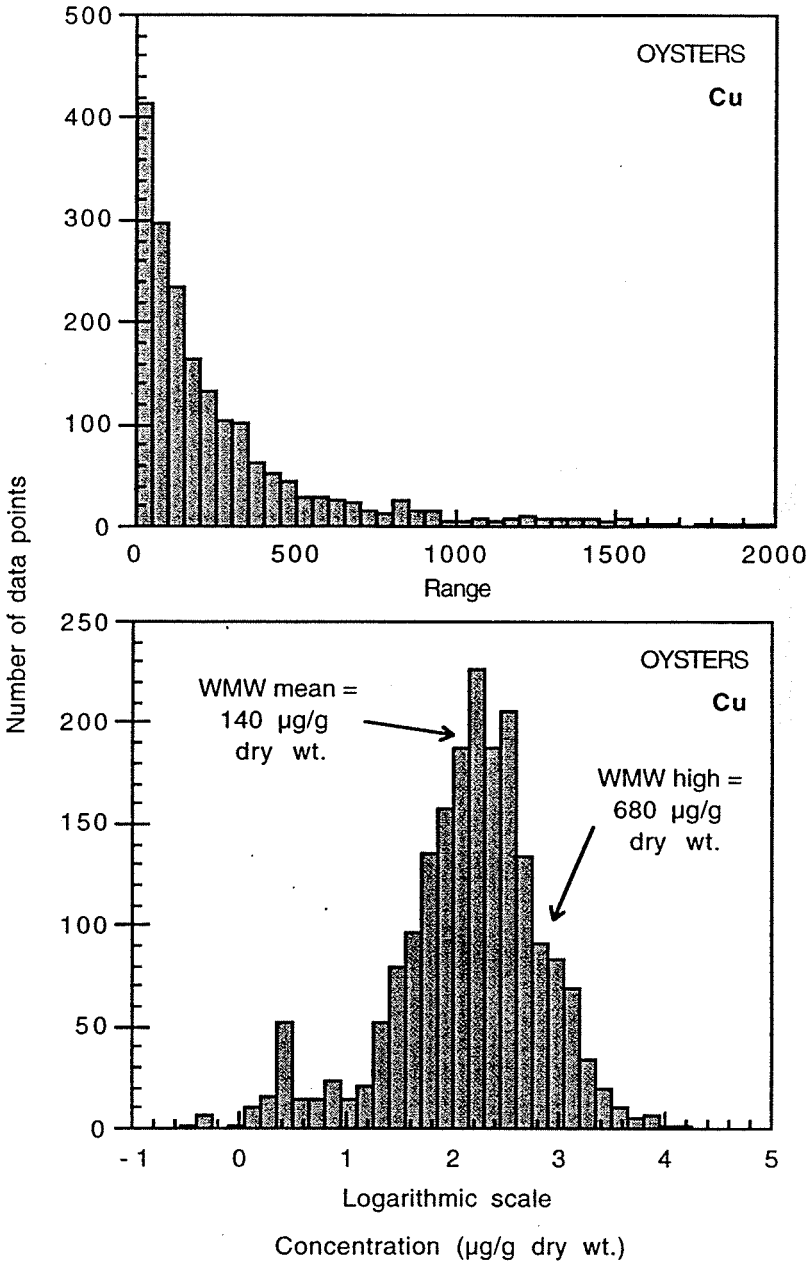

Figure IV.11. Distribution of copper in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

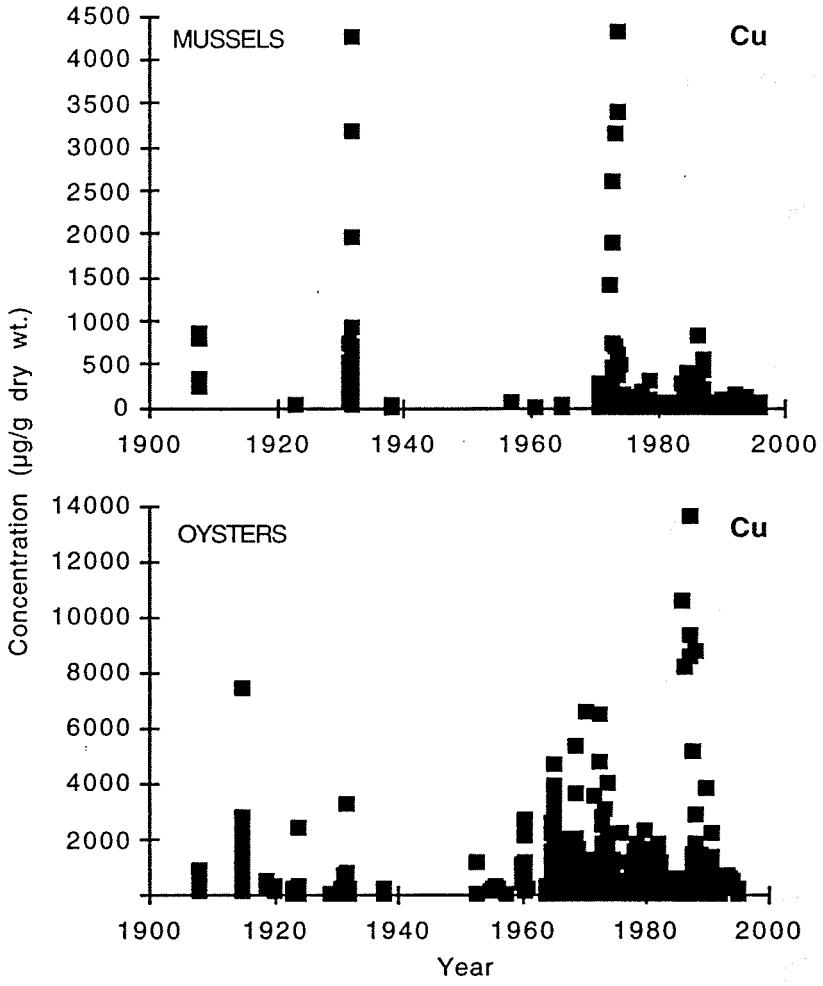

Figure IV.12. Copper data in WMW database by year (µg/g dry wt.).

IV.1.4. Zinc

4.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	2061	1726
Minimum	0	6
Maximum	14000	99000
Mean	250	3000
Median	130	1600
Standard deviation	830	5800

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.1.4.2. Graphics

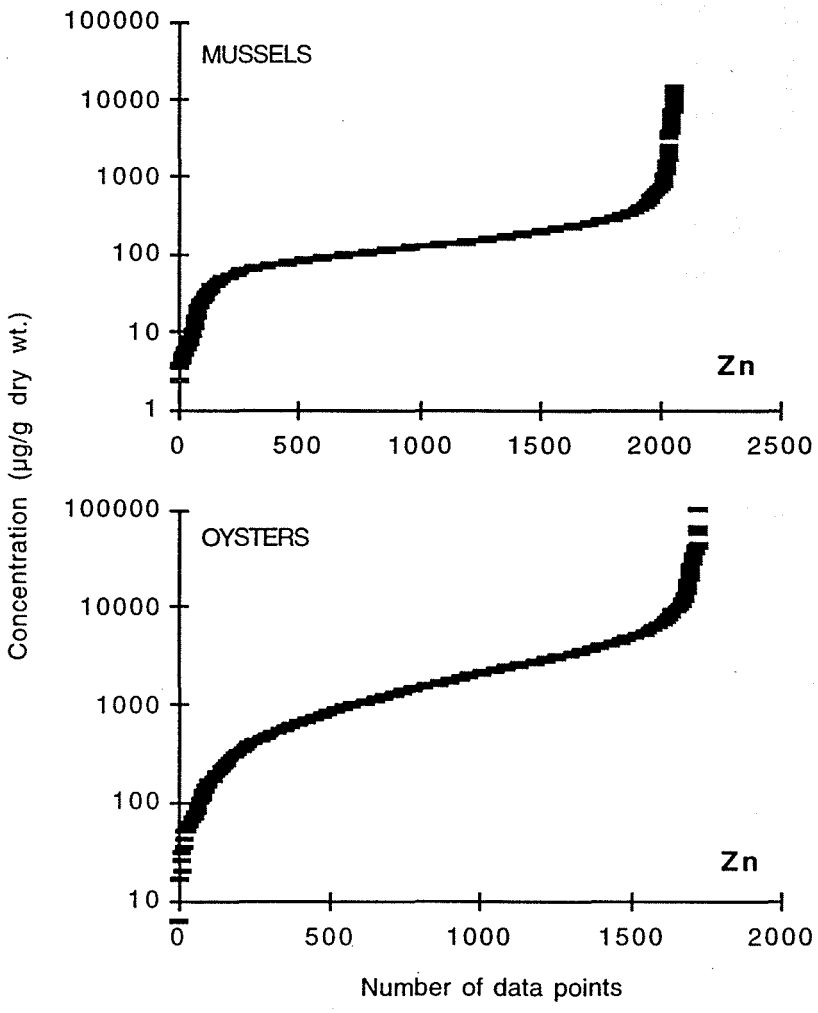

Figure IV.13. Zinc data in WMW database in increasing order (µg/g dry wt.).

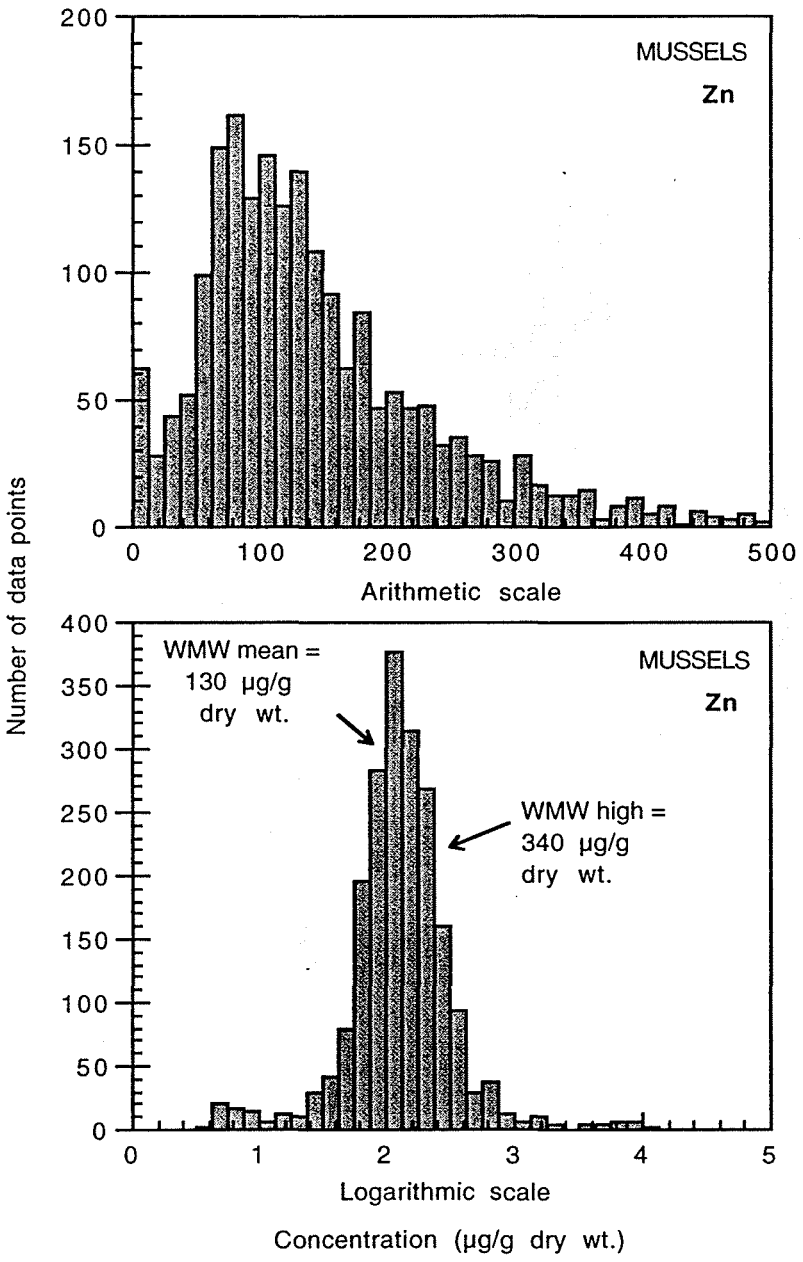

Figure IV.14. Distribution of zinc in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

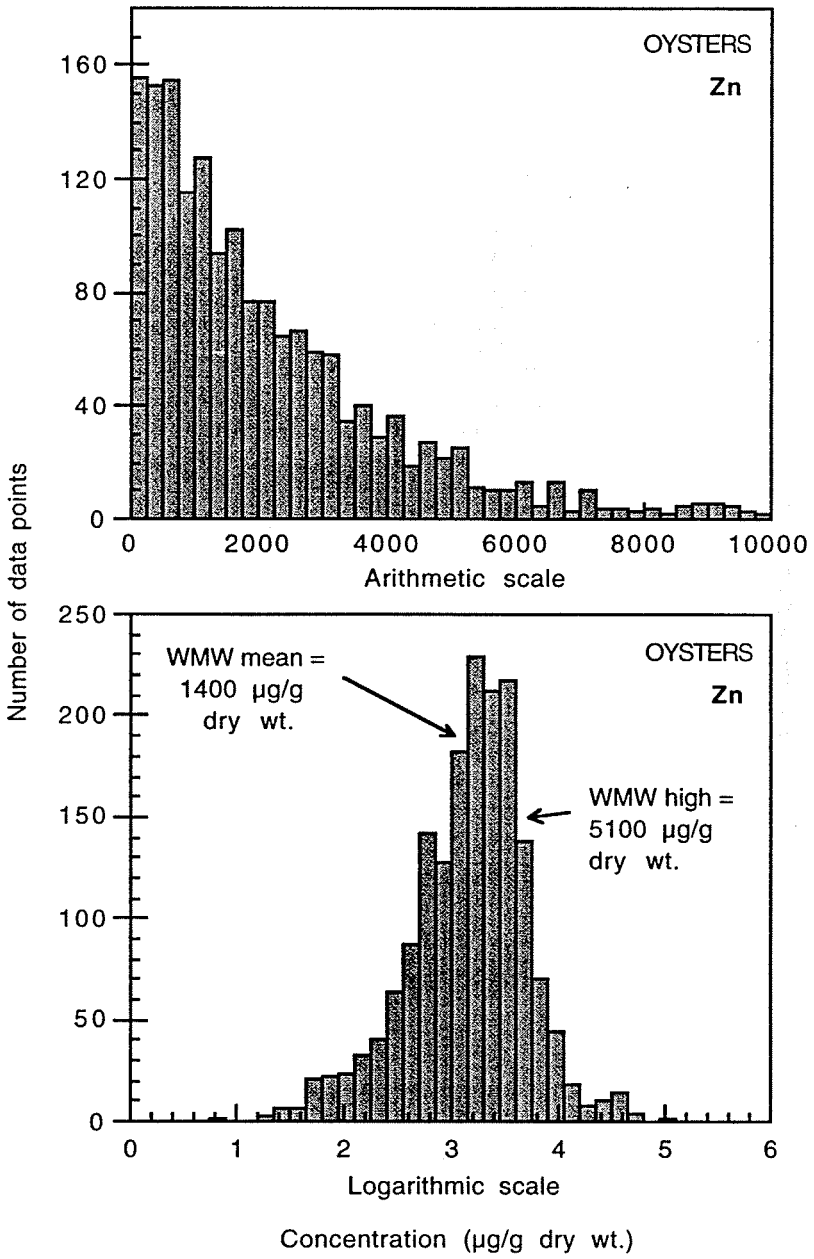

Figure IV.15. Distribution of zinc in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

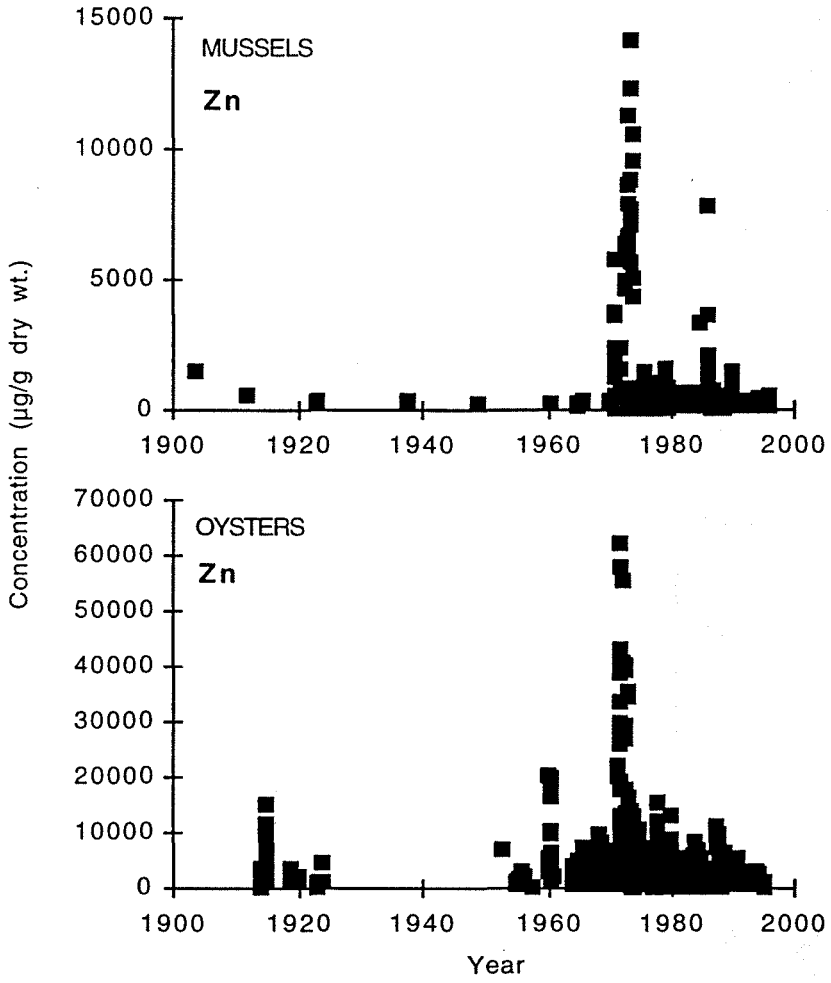

Figure IV.16. Zinc data in WMW database by year (µg/g dry wt.).

IV.1.5. Arsenic

5.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	189	279
Minimum	0.2	0
Maximum	600	920
Mean	29	16
Median	7.1	5.8
Standard deviation	88	69

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

5.2. Graphics

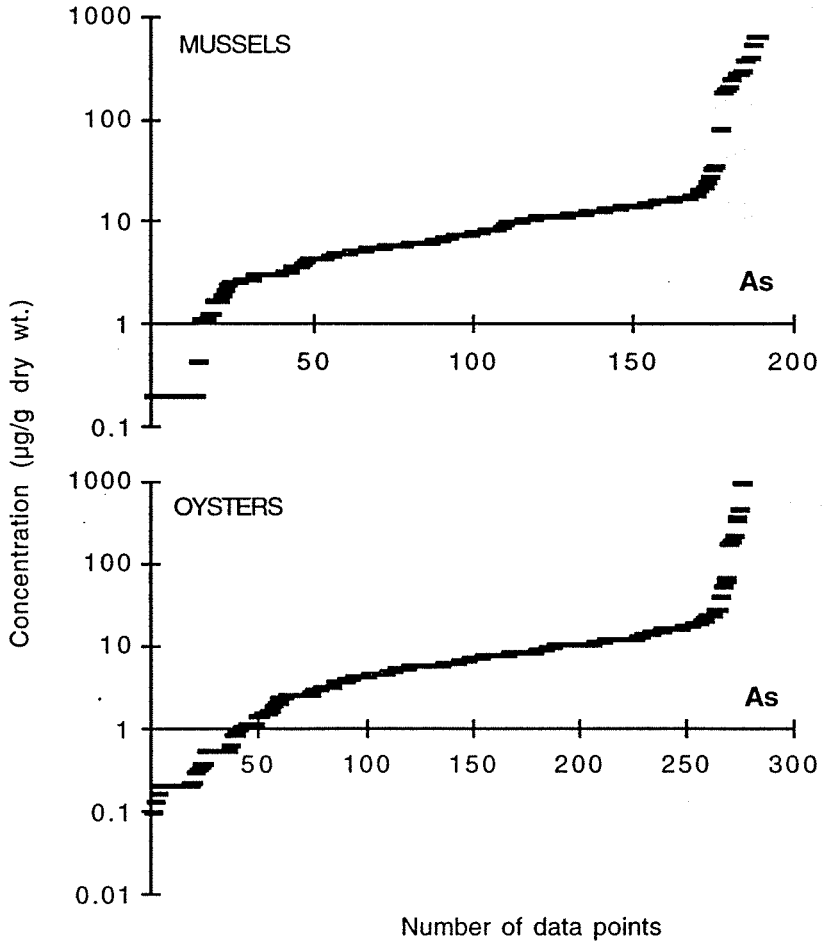

Figure IV.17. Arsenic data in WMW database in increasing order (µg/g dry wt.).

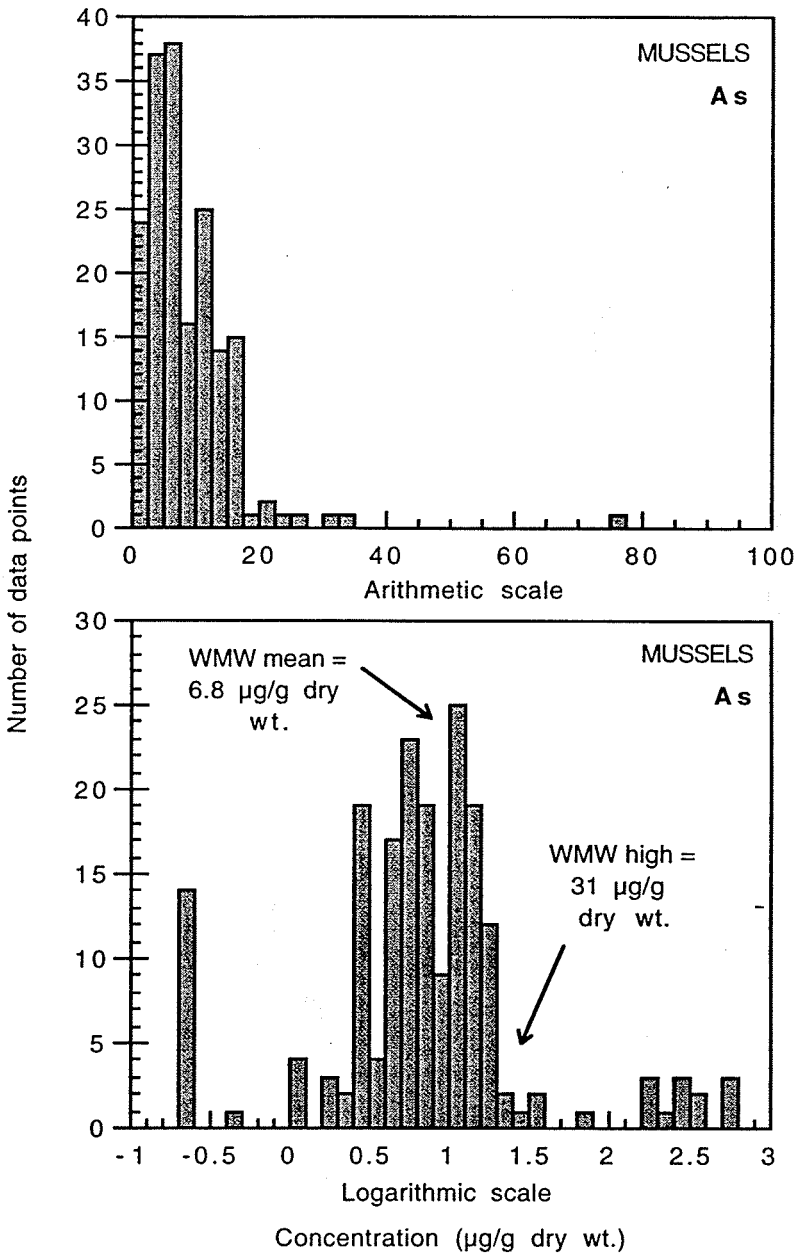

Figure IV.18. Distribution of arsenic in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

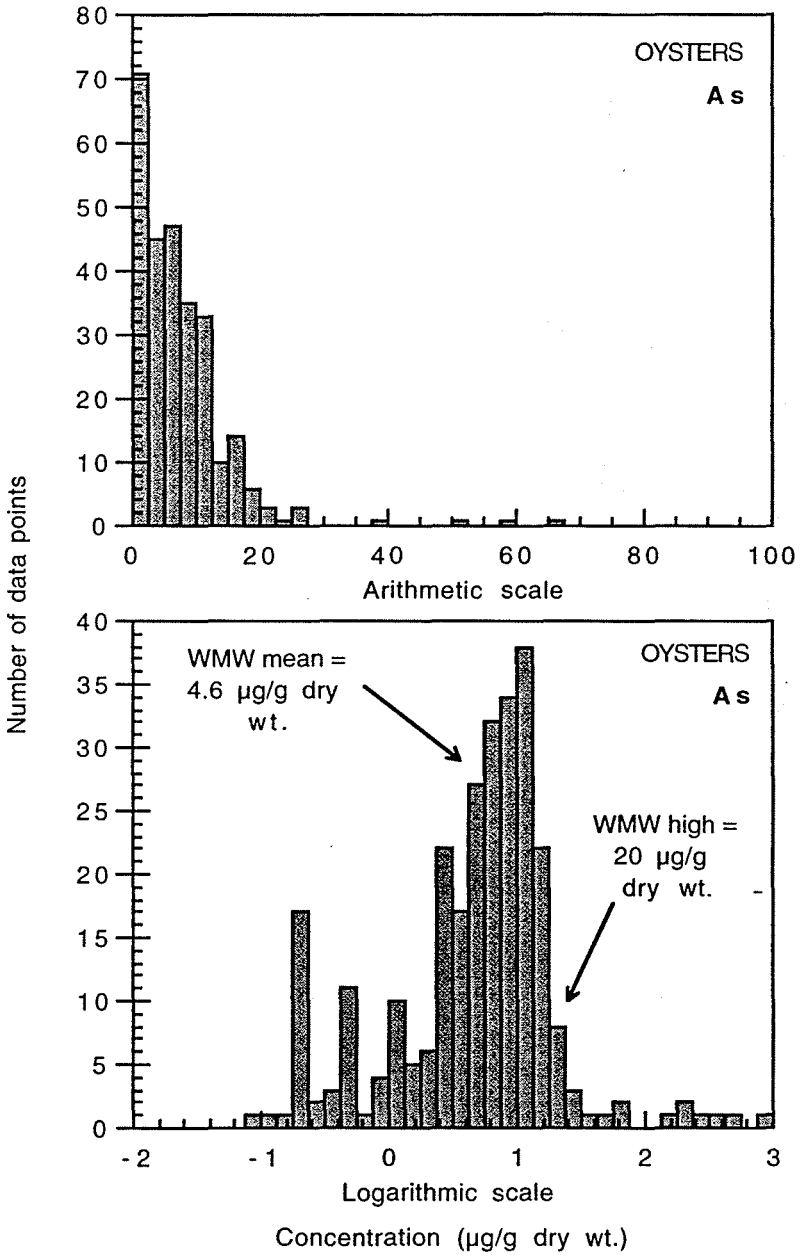

Figure IV.19. Distribution of arsenic in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

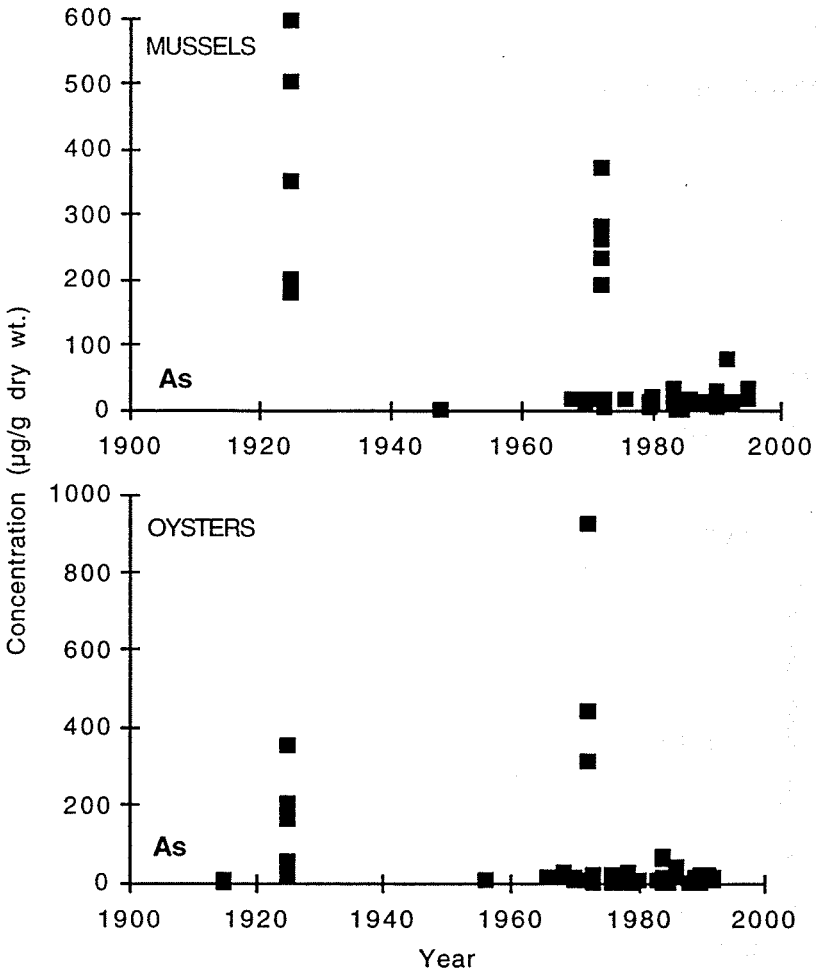

Figure IV.20. Arsenic data in WMW database by year (µg/g dry wt.).

IV.1.6. Selenium

6.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	95	-
Minimum	0.01	-
Maximum	27	-
Mean	3.2	-
Median	2.2	-
Standard deviation	3.8	-

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

6.2. Graphics

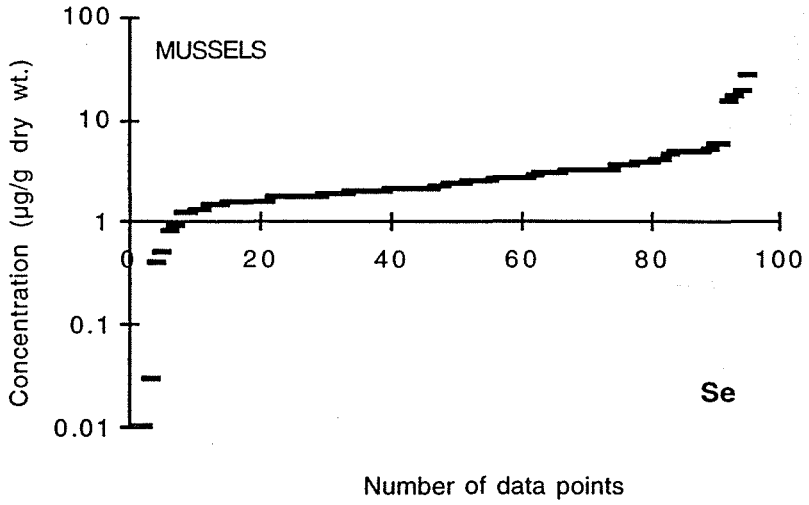

Figure IV.21. Selenium data in WMW database in increasing order (µg/g dry wt.).

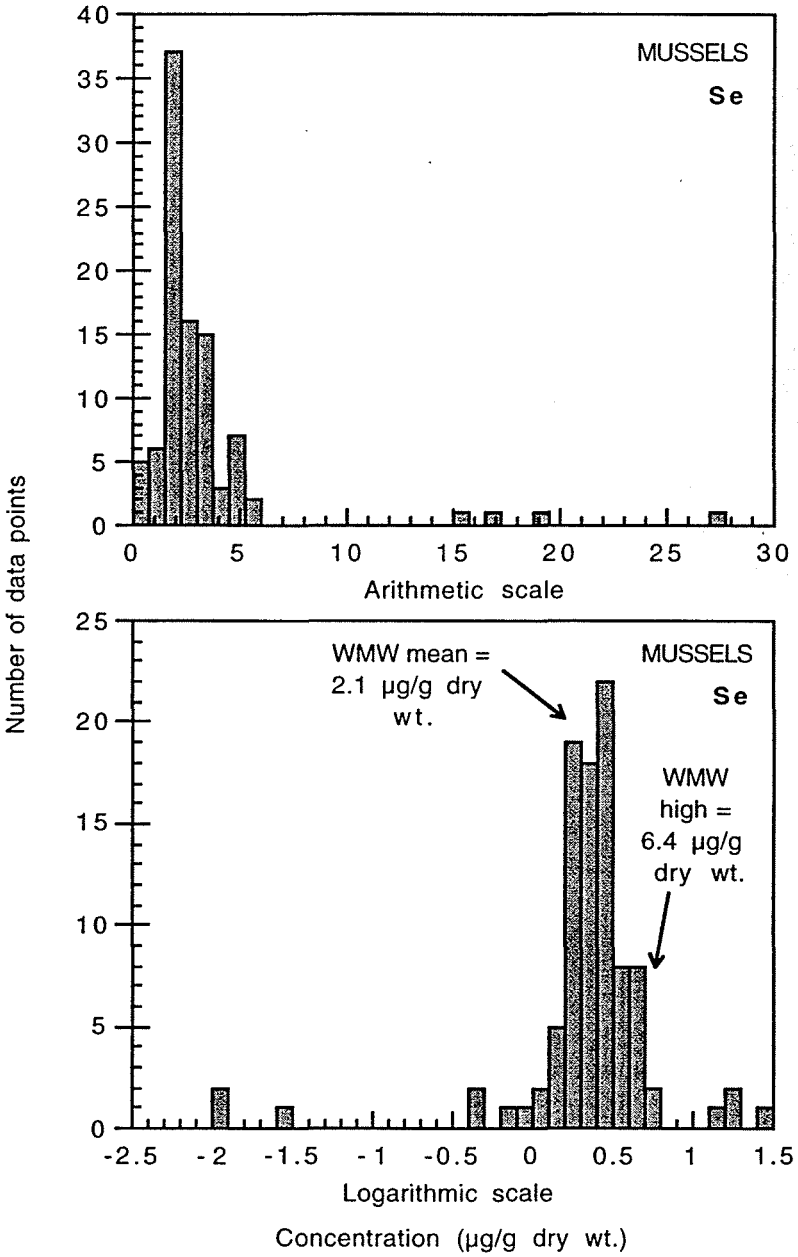

Figure IV.22. Distribution of selenium in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

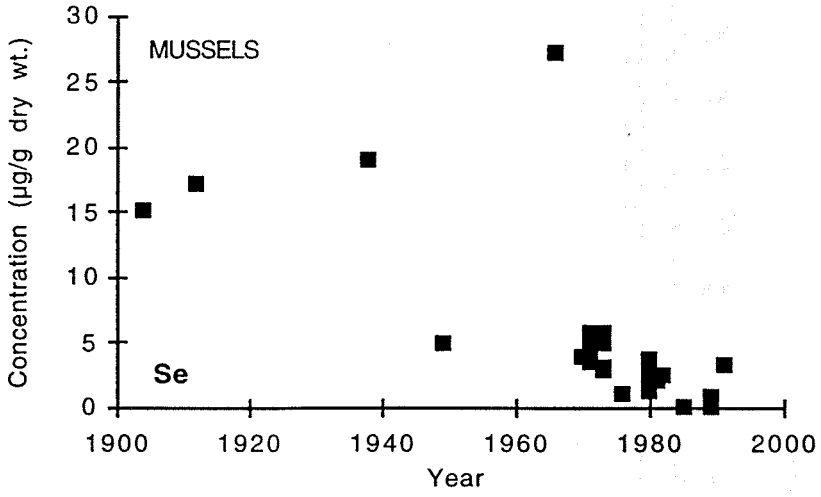

Figure IV.23. Selenium data in WMW database by year (µg/g dry wt.).

IV.1.7. Silver

7.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	444	250
Minimum	0	0.1
Maximum	82	36
Mean	1.1	1.9
Median	0.25	1.3
Standard deviation	5.7	2.8

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

7.2. Graphics

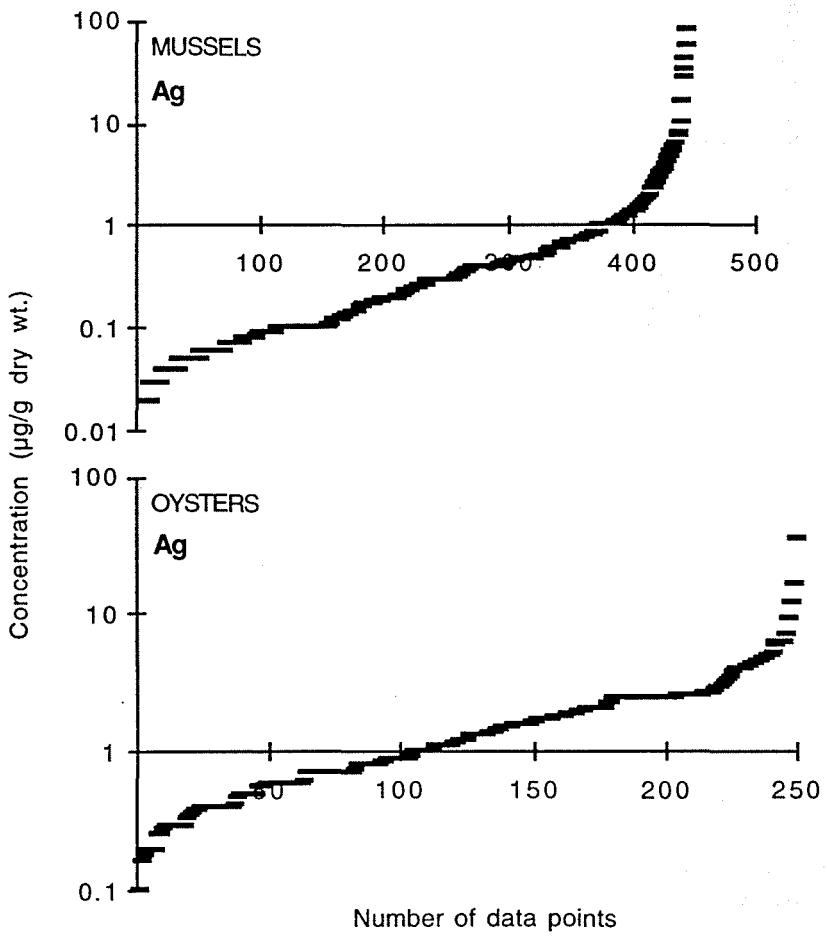

Figure IV.24. Silver data in WMW database in increasing order (µg/g dry wt.).

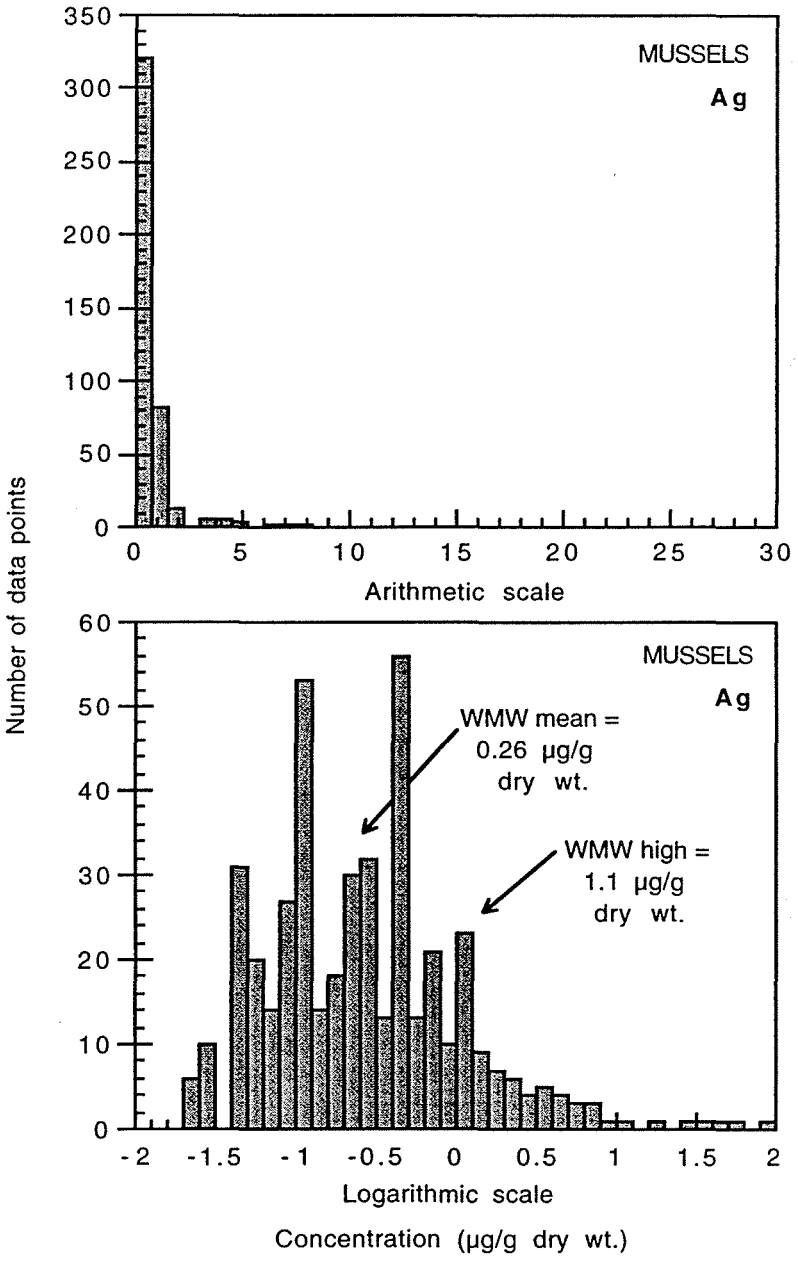

Figure IV.25. Distribution of silver in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

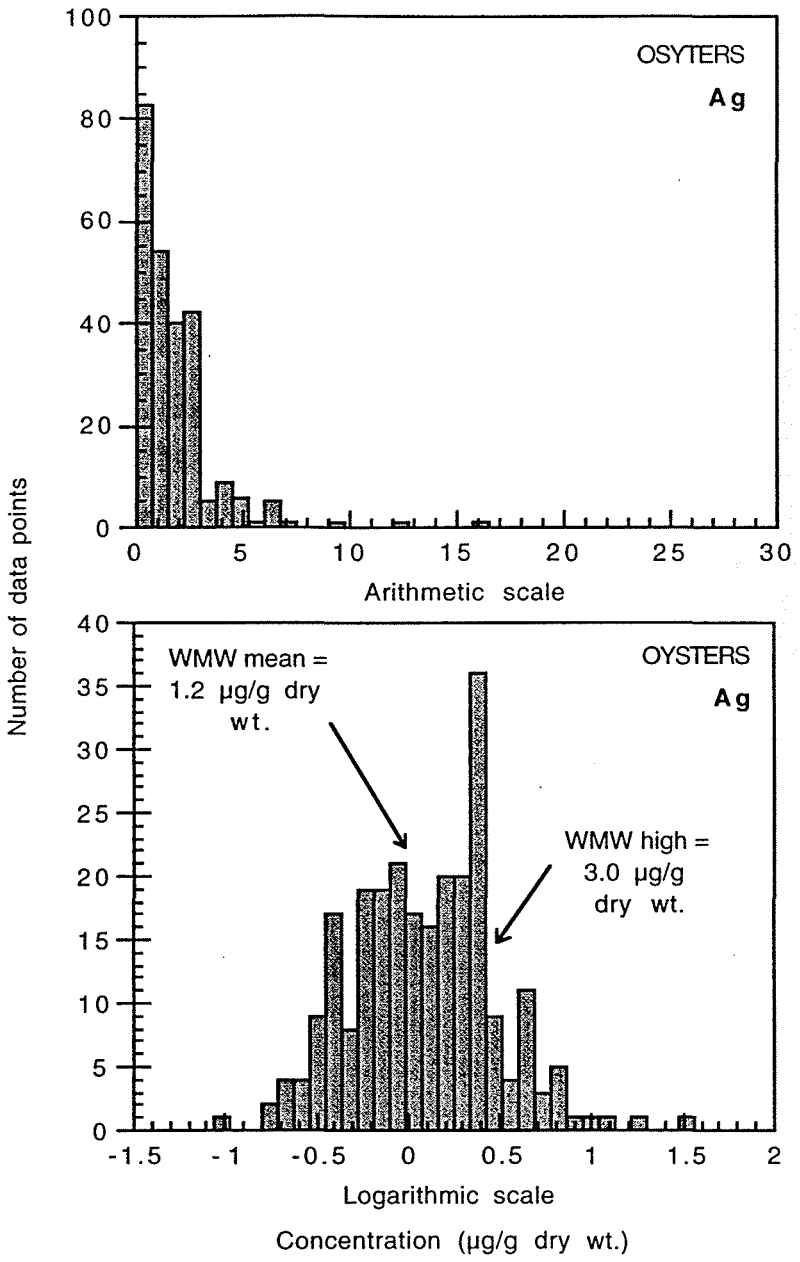

Figure IV.26. Distribution of silver in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

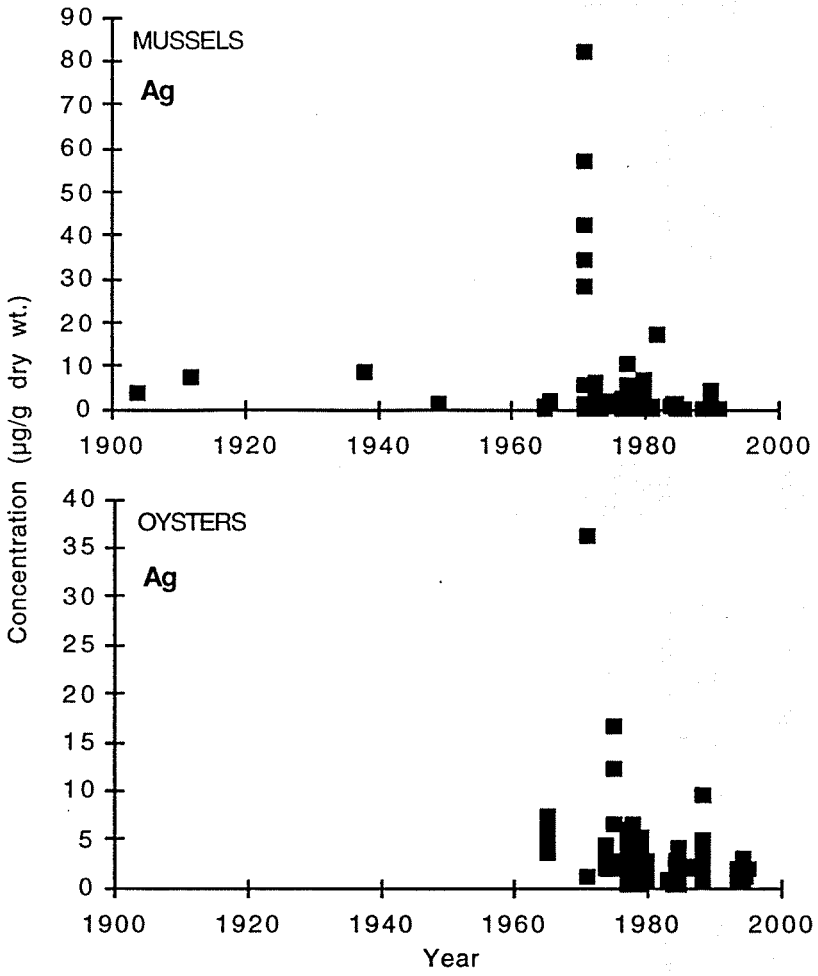

Figure IV.27. Silver data in WMW database by year (µg/g dry wt.).

IV.1.8. Cadmium

8.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	1993	1295
Minimum	0	0
Maximum	370	200
Mean	5.3	12
Median	2.0	4.1
Standard deviation	13	21

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

8.2. Graphics

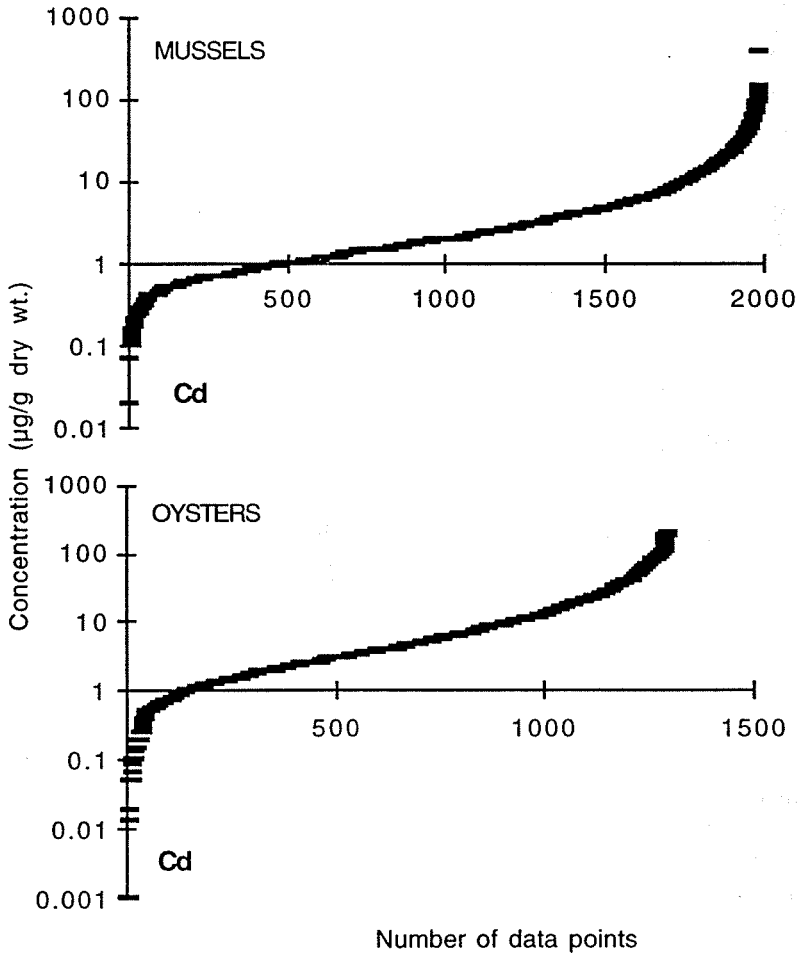

Figure IV.28. Cadmium data in WMW database in increasing order (µg/g dry wt.).

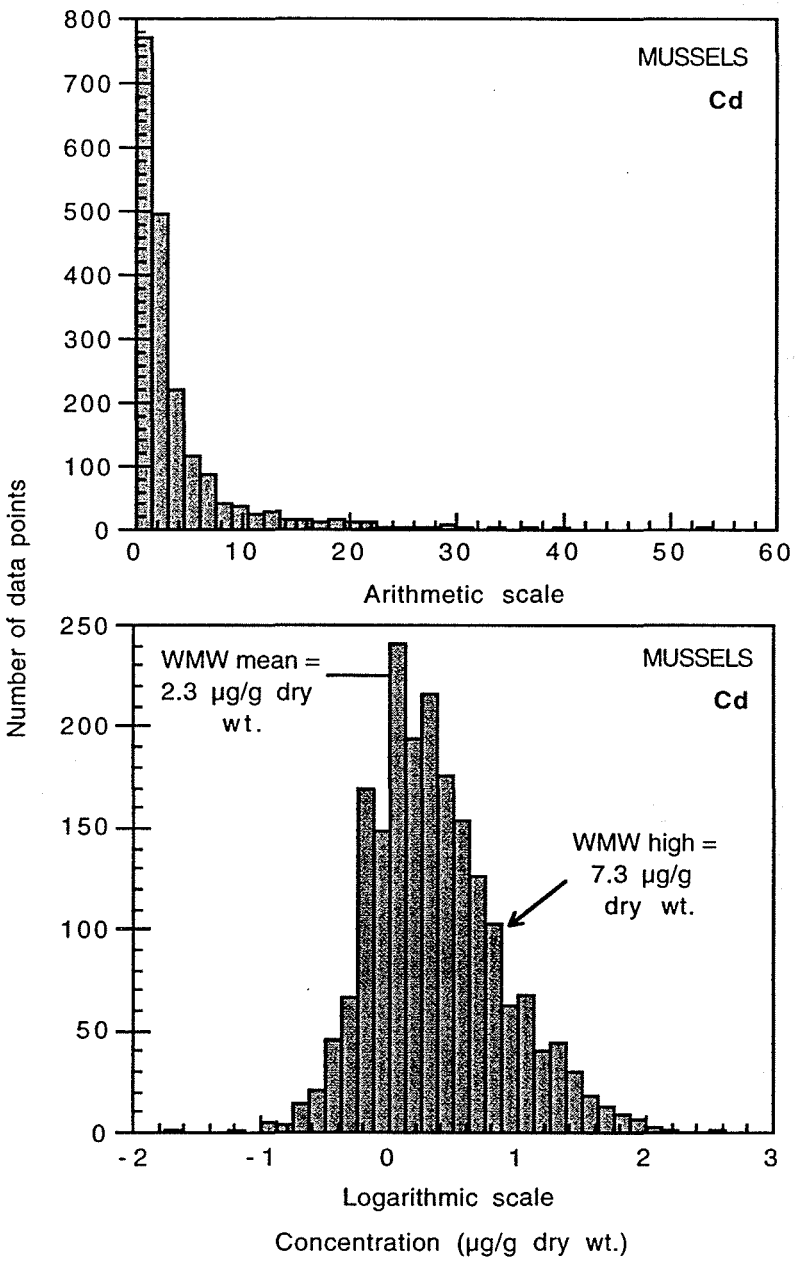

Figure IV.29. Distribution of cadmium in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

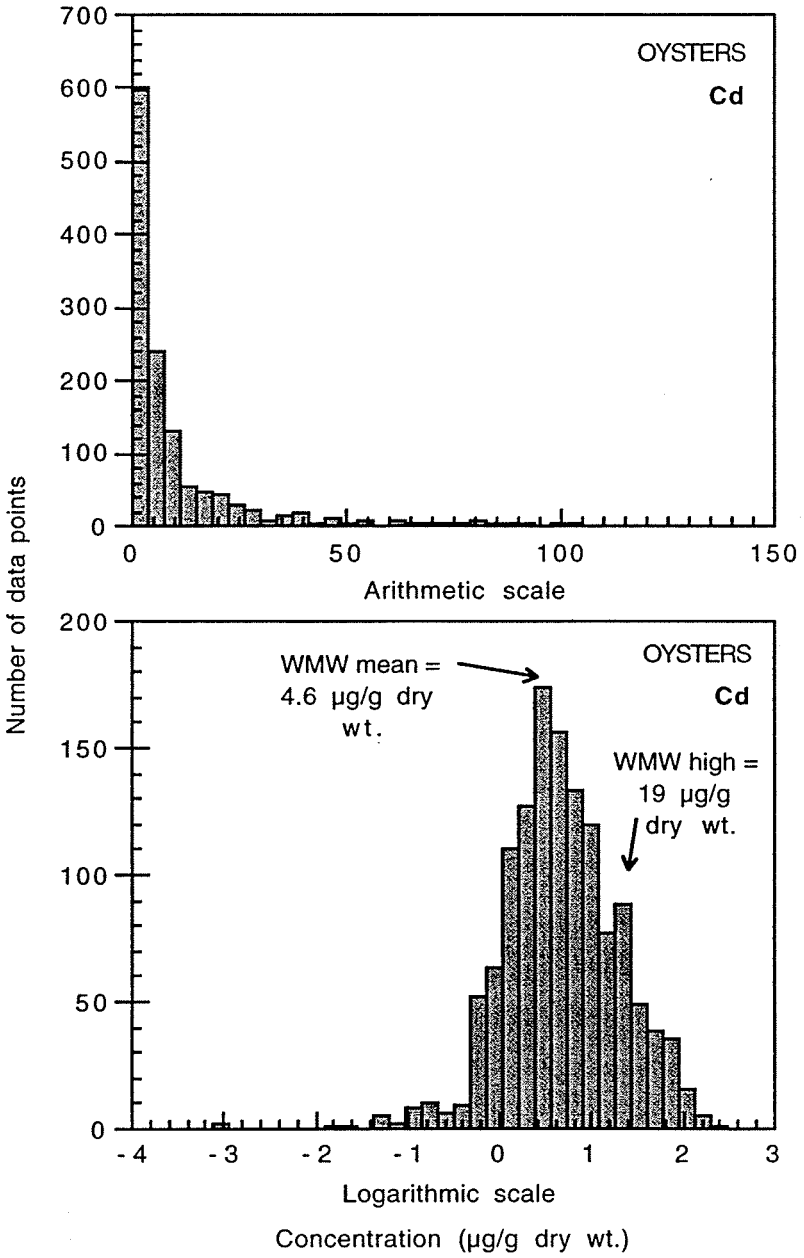

Figure IV.30. Distribution of cadmium in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

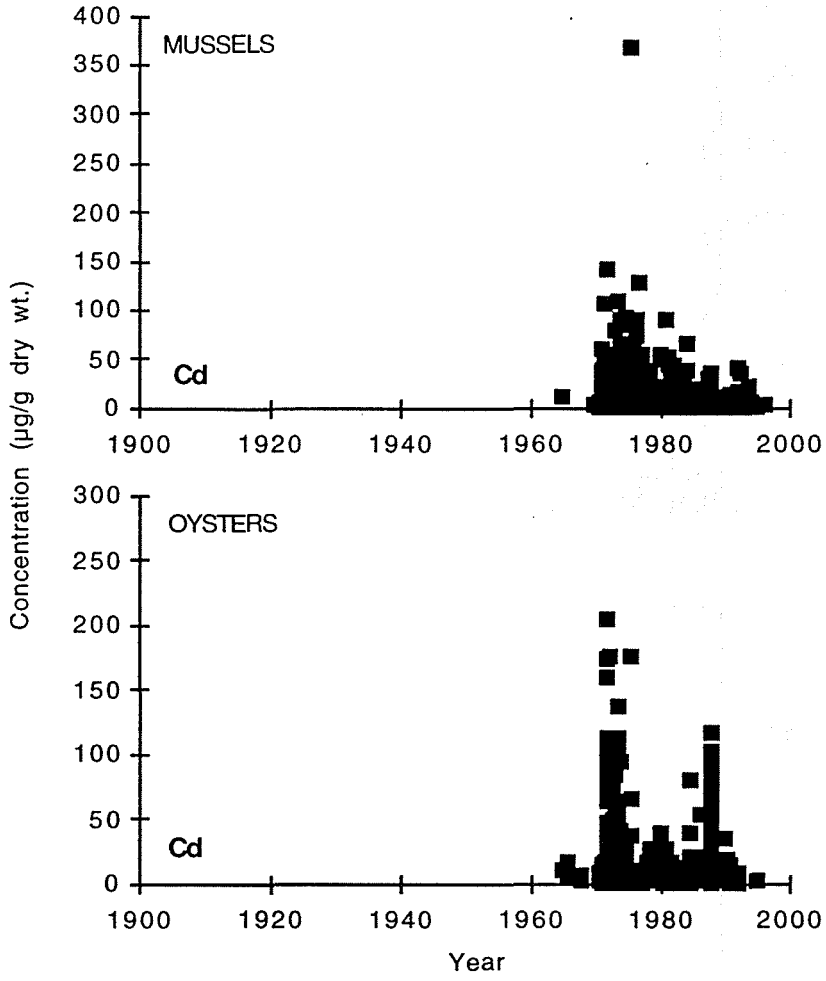

Figure IV.31. Cadmium data in WMW database by year (µg/g dry wt.).

IV.1.9. Tin

IV.1.9.1. Basic statistics

There were not sufficient data to calculate statistics.

IV.1.9.2. Graphics

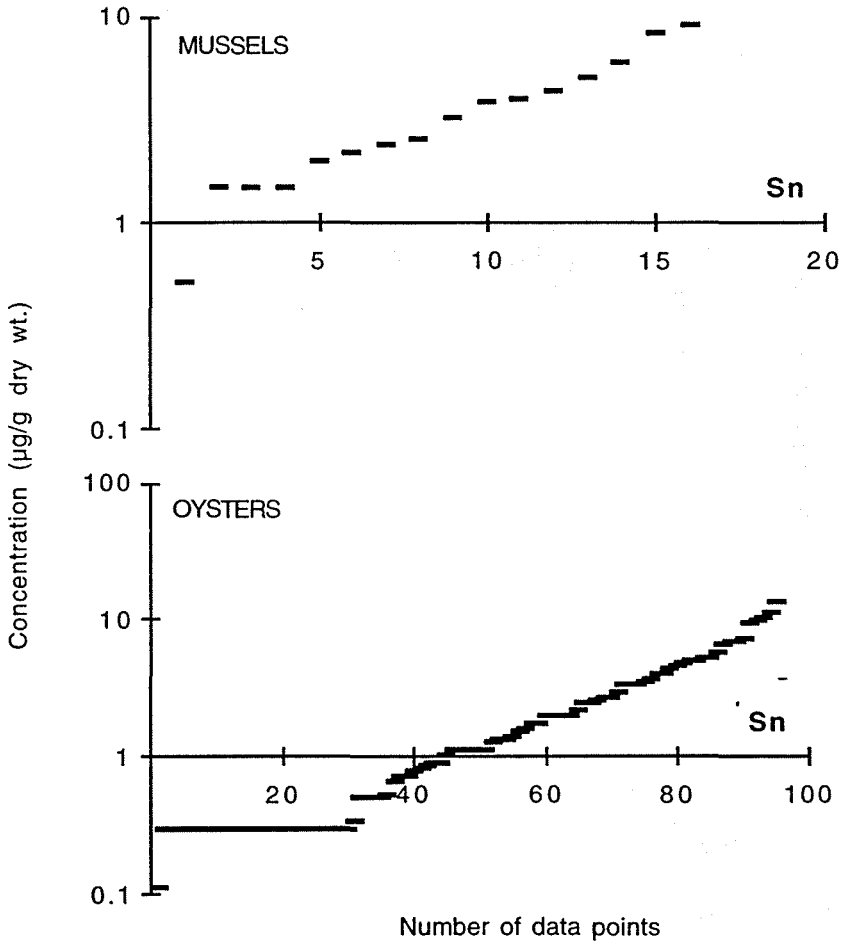

Figure IV.32. Tin data in WMW database in increasing order (µg/g dry wt.).

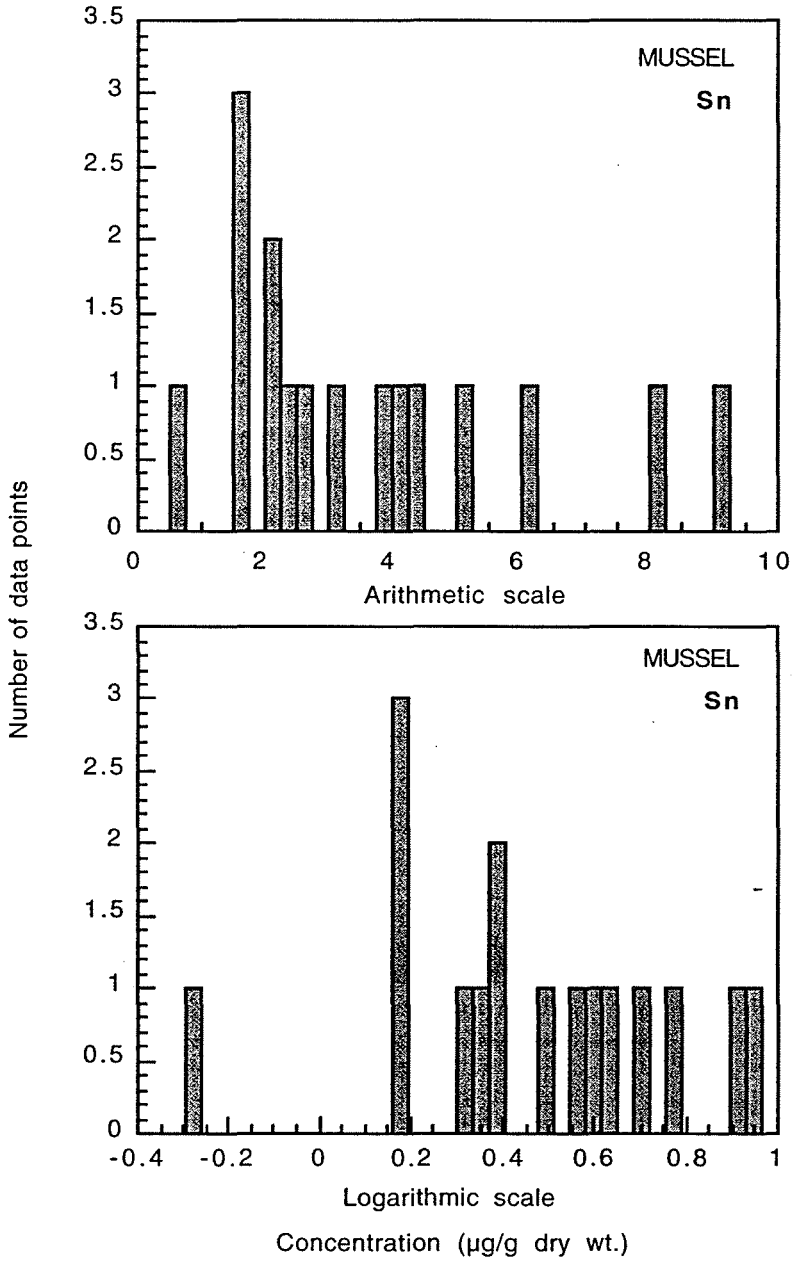

Figure IV.33. Distribution of tin in mussels on arithmetic and logarithmic scales (µg/g dry wt.).

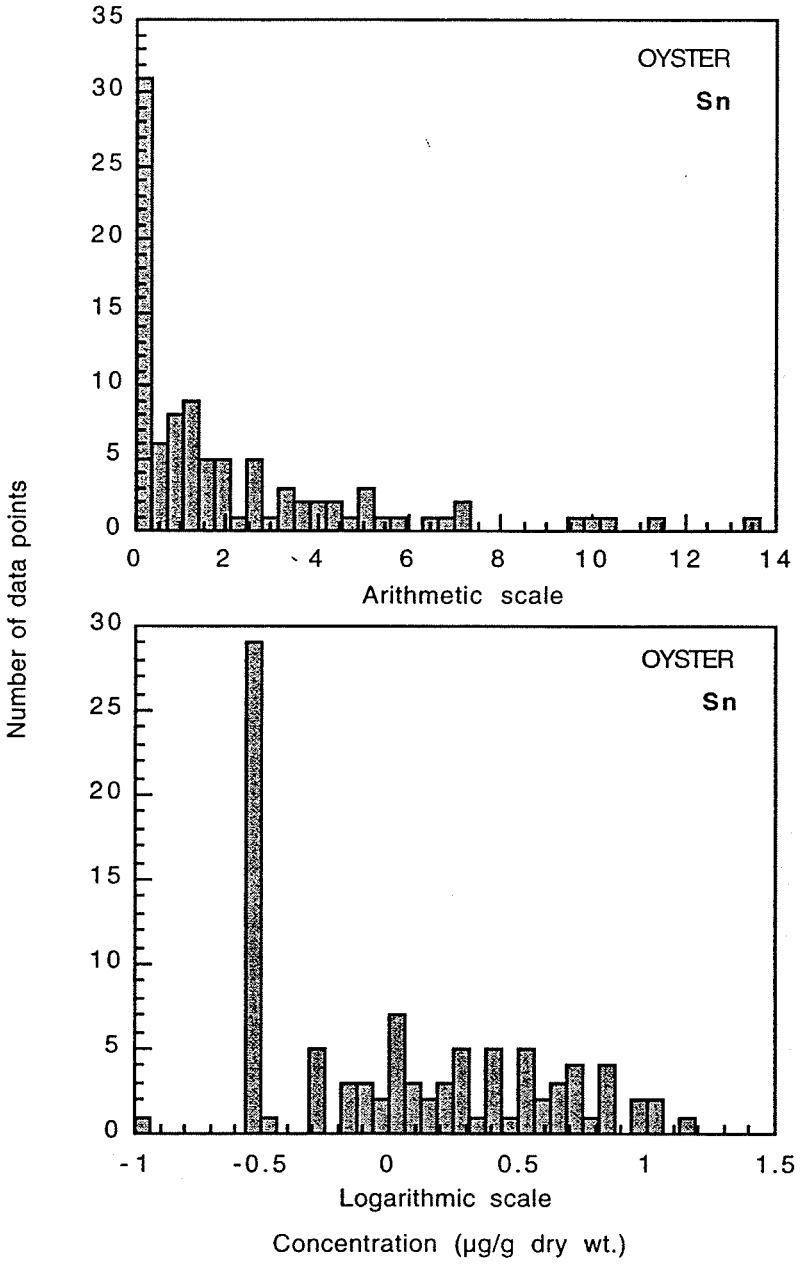

Figure IV.34. Distribution of tin in oysters on arithmetic and logarithmic scales (µg/g dry wt.).

IV.1.10. Mercury

10.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	948	541
Minimum	0	0.003
Maximum	1900	33
Mean	7.9	0.50
Median	0.31	0.27
Standard deviation	73	1.5

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

10.2. Graphics

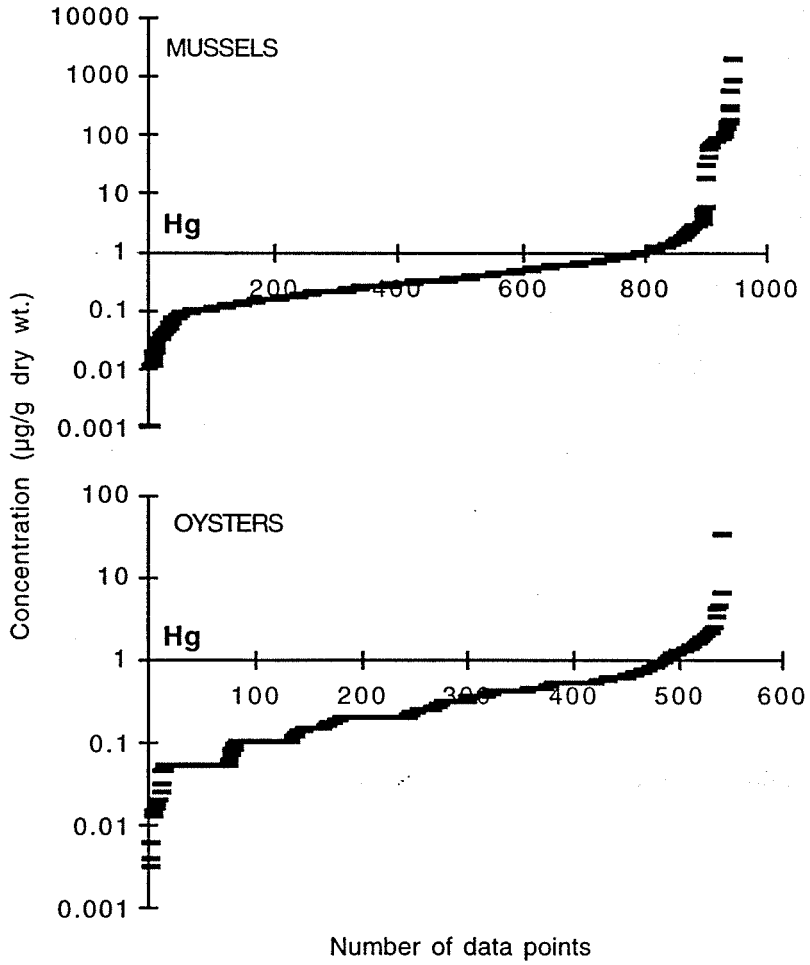

Figure IV.35. Mercury data in WMW database in increasing order (µg/g dry wt.).

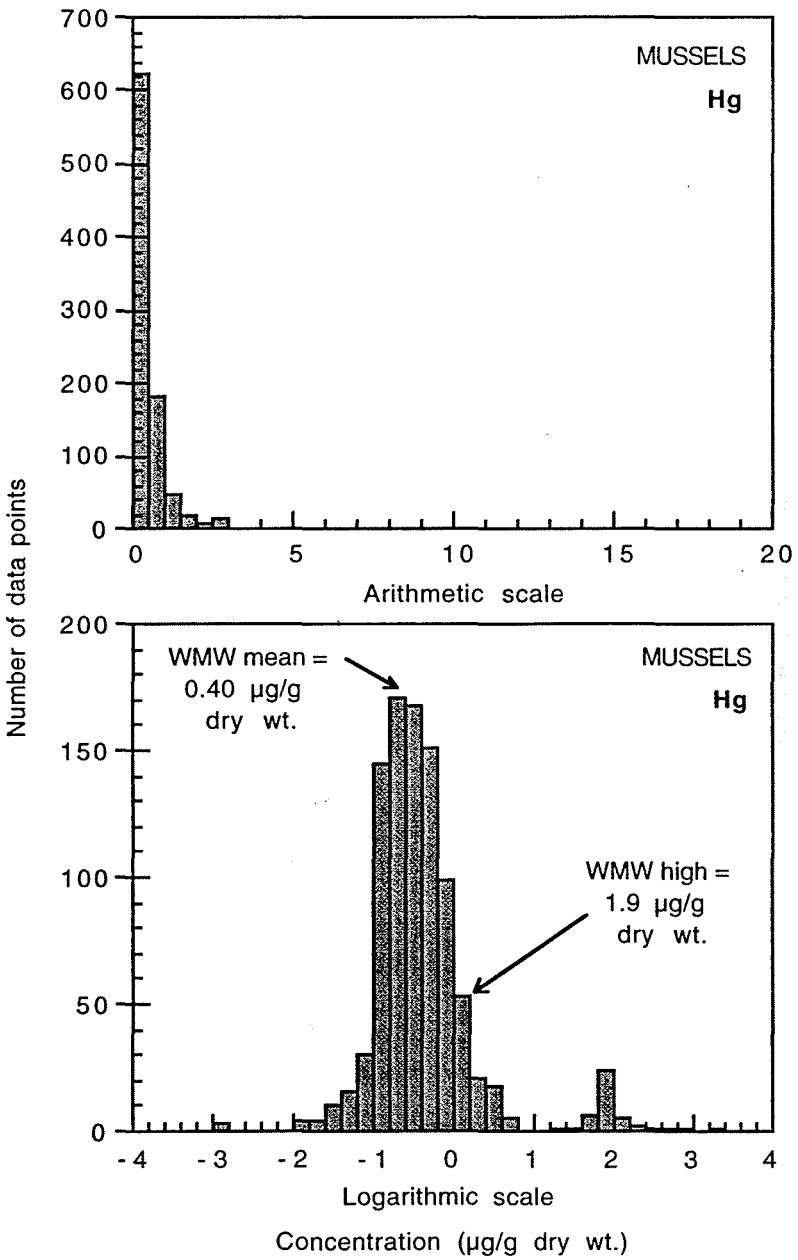

Figure IV.36. Distribution of mercury in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

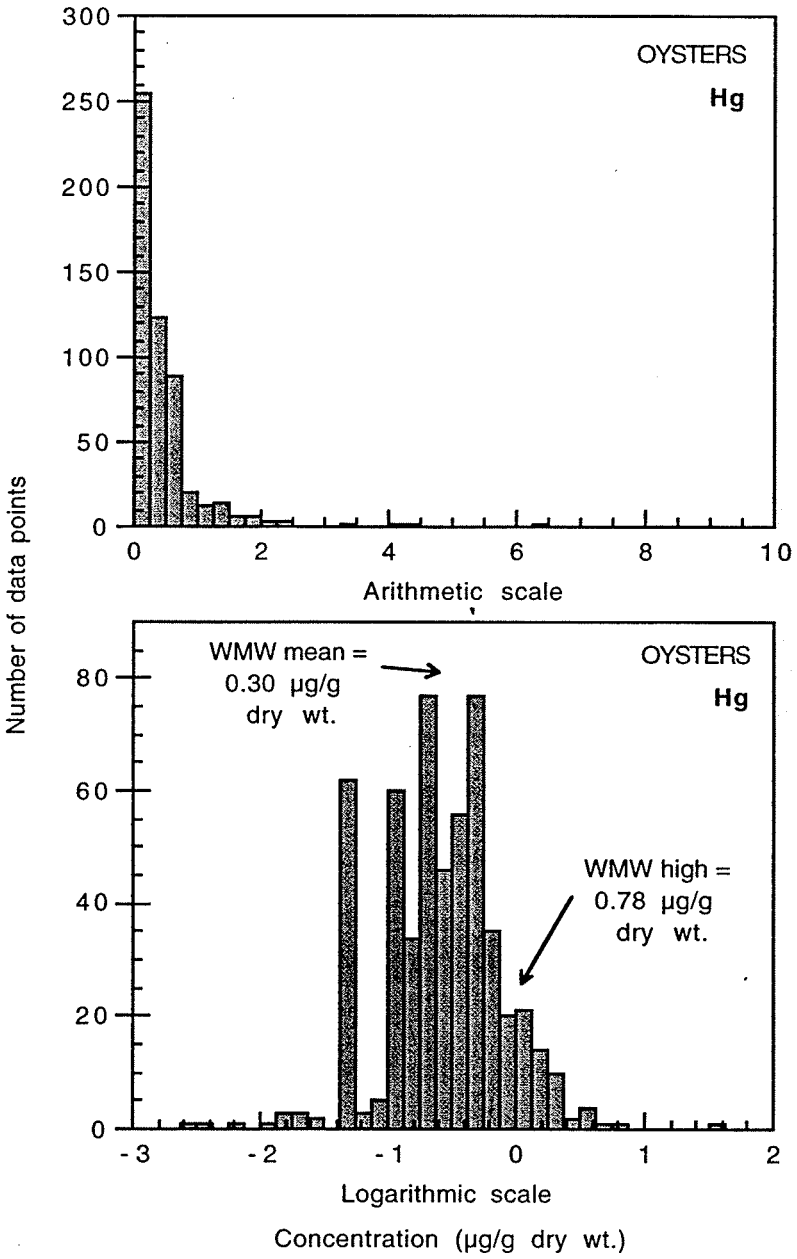

Figure IV.37. Distribution of mercury in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

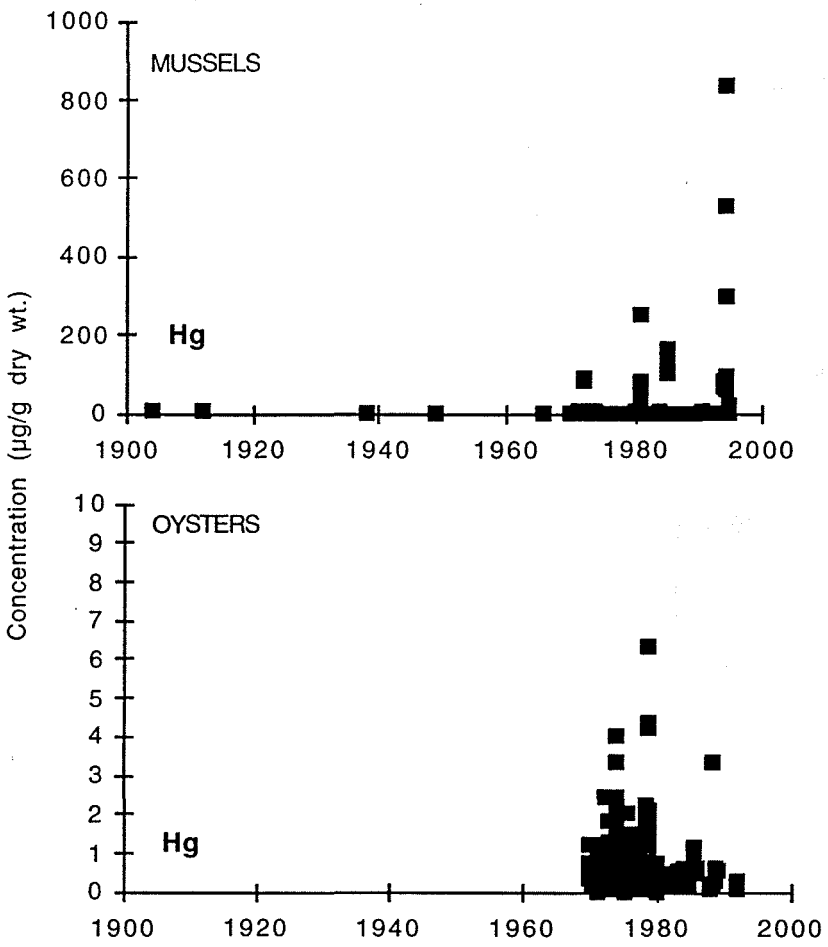

Figure IV.38. Mercury data in WMW database by year (µg/g dry wt.). (Som high values not shown.)

IV.1.11. Lead

11.1. Basic statistics* (µg/g dry wt.)

	Mussels	Oysters
Number of values	1857	969
Minimum	0	0
Maximum	6500	400
Mean	28	5.6
Median	5	2.5
Standard deviation	230	18

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

11.2. Graphics

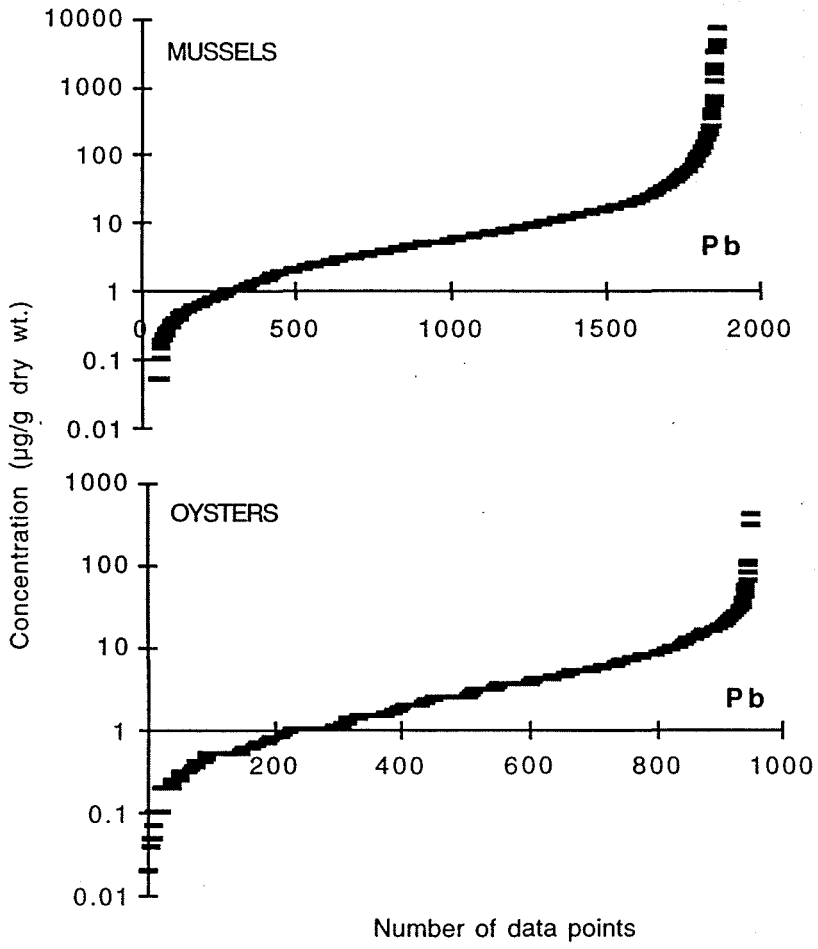

Figure IV.39. Lead data in WMW database in increasing order (µg/g dry wt.).

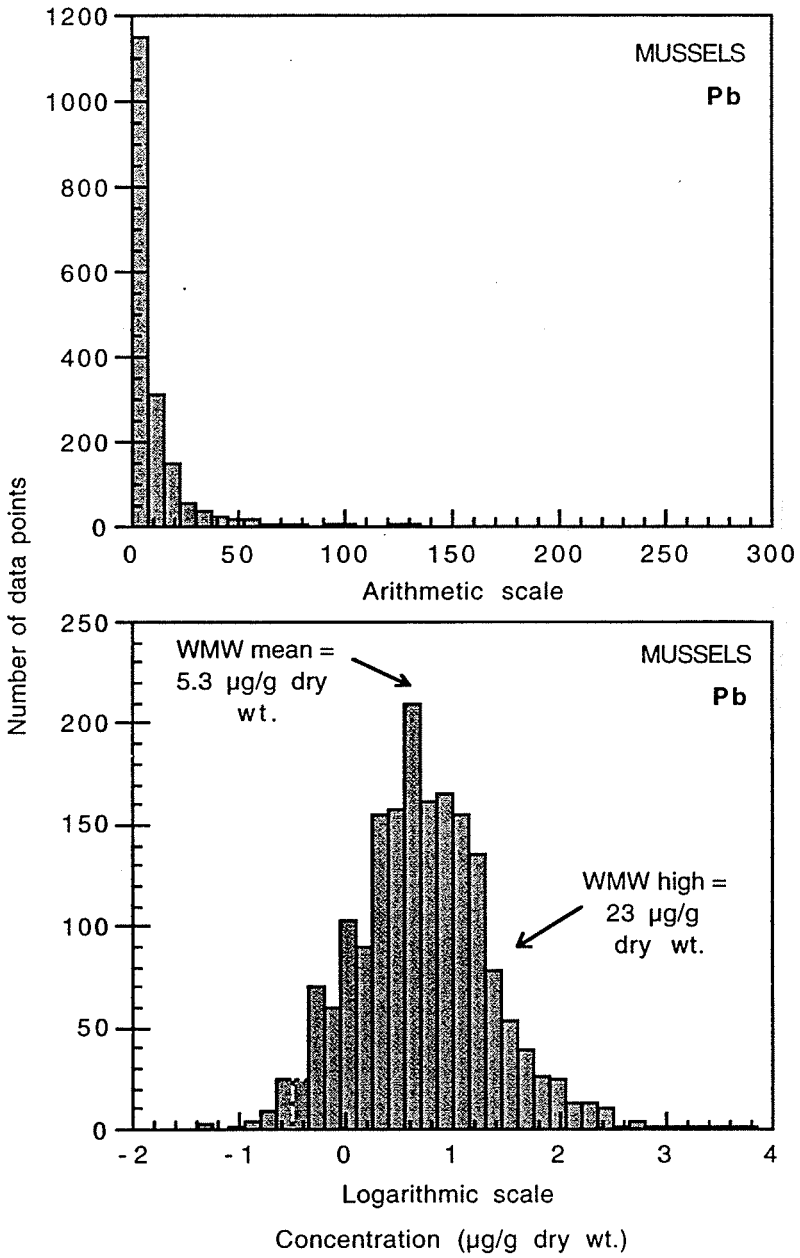

Figure IV.40. Distribution of lead in mussels on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

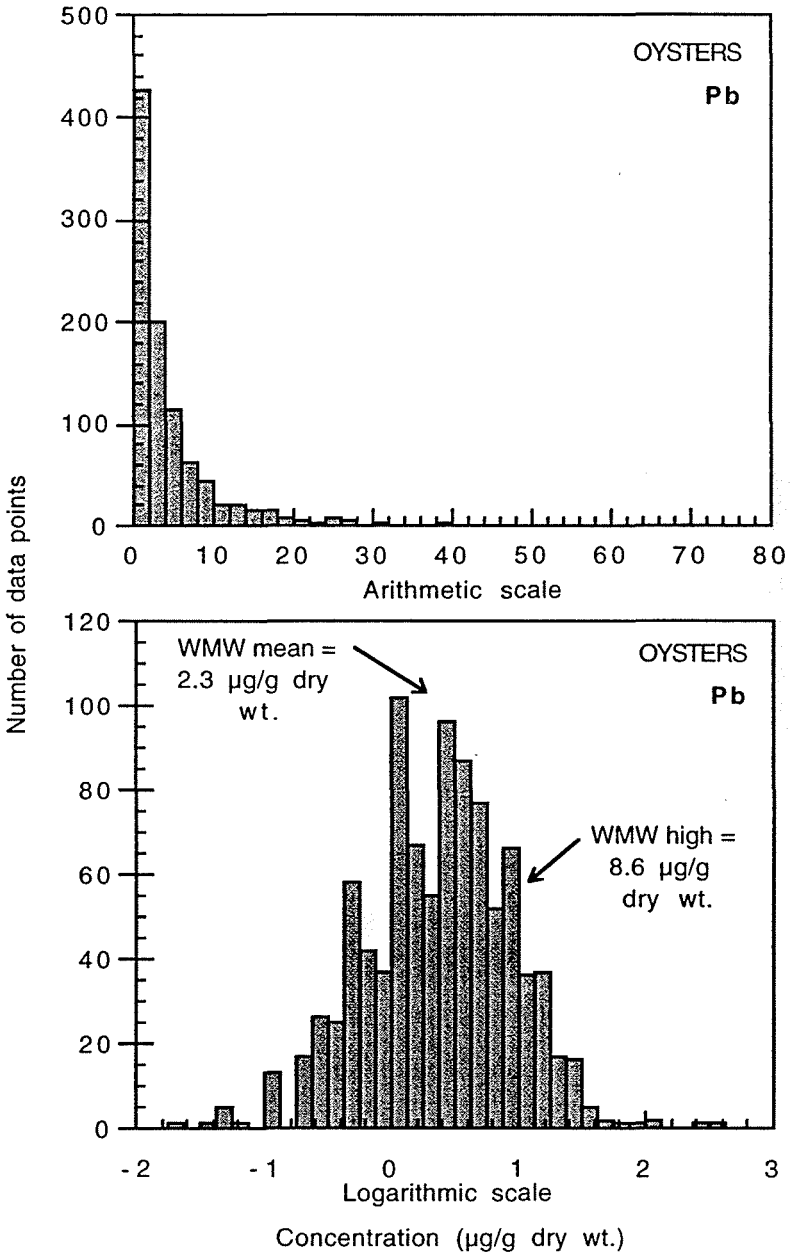

Figure IV.41. Distribution of lead in oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data used in calculations. Some high concentrations not shown.)

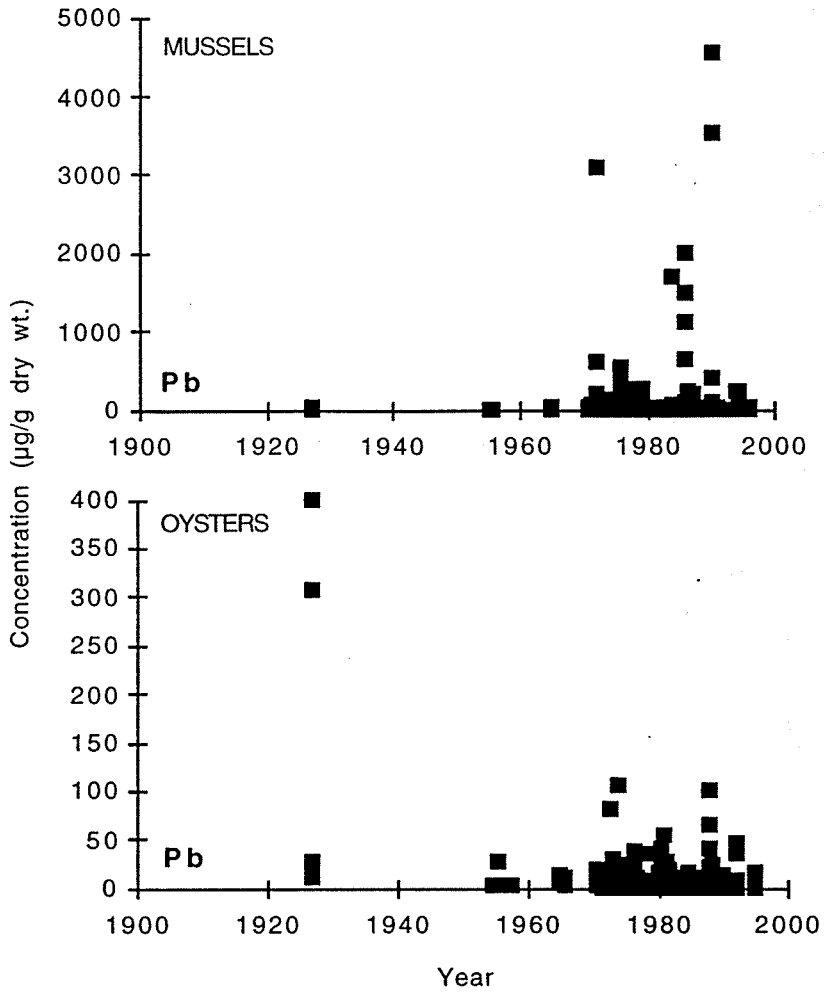

Figure IV.42. Lead data in WMW database by year (µg/g dry wt.). (High value of 1300 µg/g wet wt. in mussels not shown.)

IV.2. Combined mussel and oyster species

IV.2.1. Chromium

IV.2.1.1. Basic statistics* (µg/g dry wt.)

Number of values	1073
Minimum	0
Maximum	435
Mean	5.7
Median	2
Standard deviation	22

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.1.2. Graphics

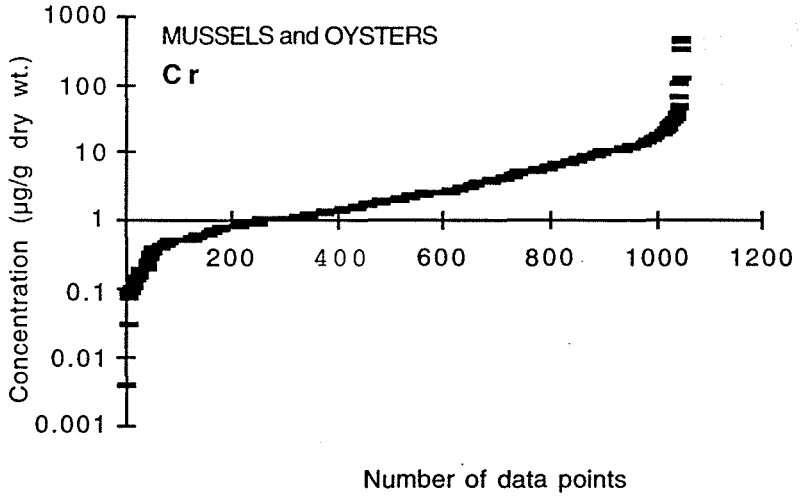

Figure IV.43. Chromium data in combined WMW database in increasing order (µg/g dry wt.).

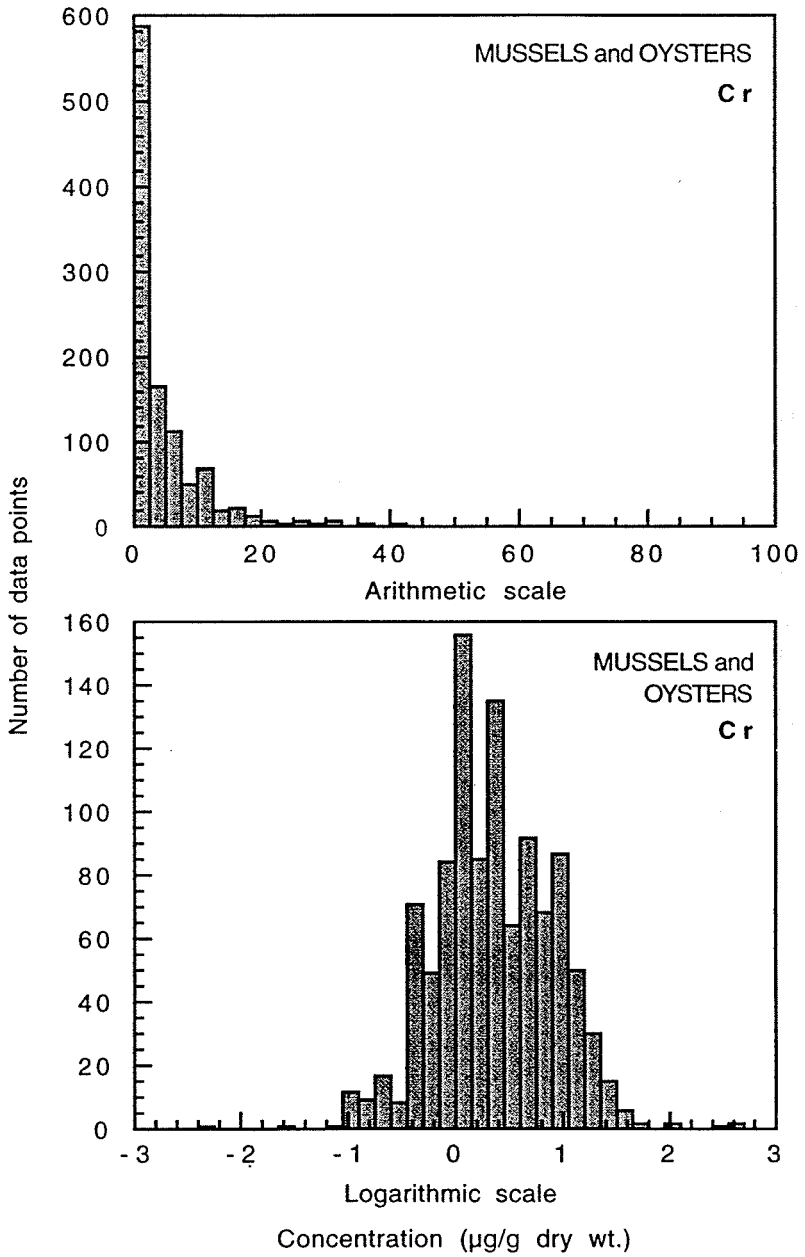

Figure IV.44. Distribution of chromium in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.2.2. Nickel

IV.2.2.1. Basic statistics* (µg/g dry wt.)

Number of values	1103
Minimum	0
Maximum	2350
Mean	6.0
Median	2
Standard deviation	71

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.2.2. Graphics

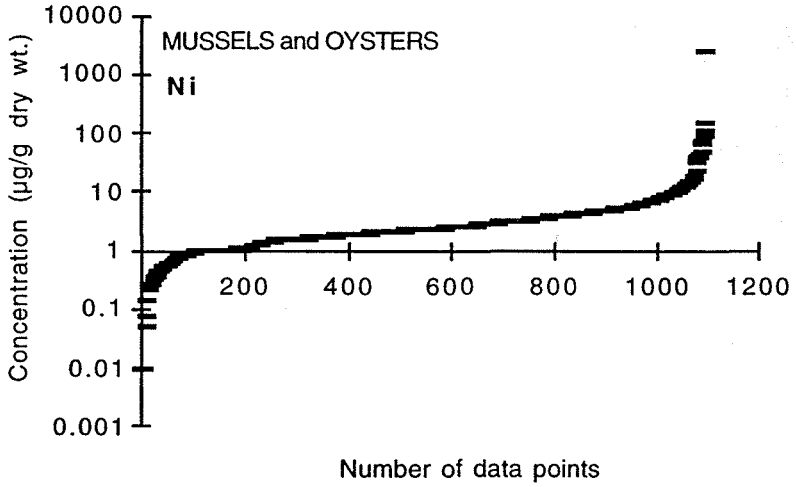

Figure IV.45. Nickel data in combined WMW database in increasing order (µg/g dry wt.).

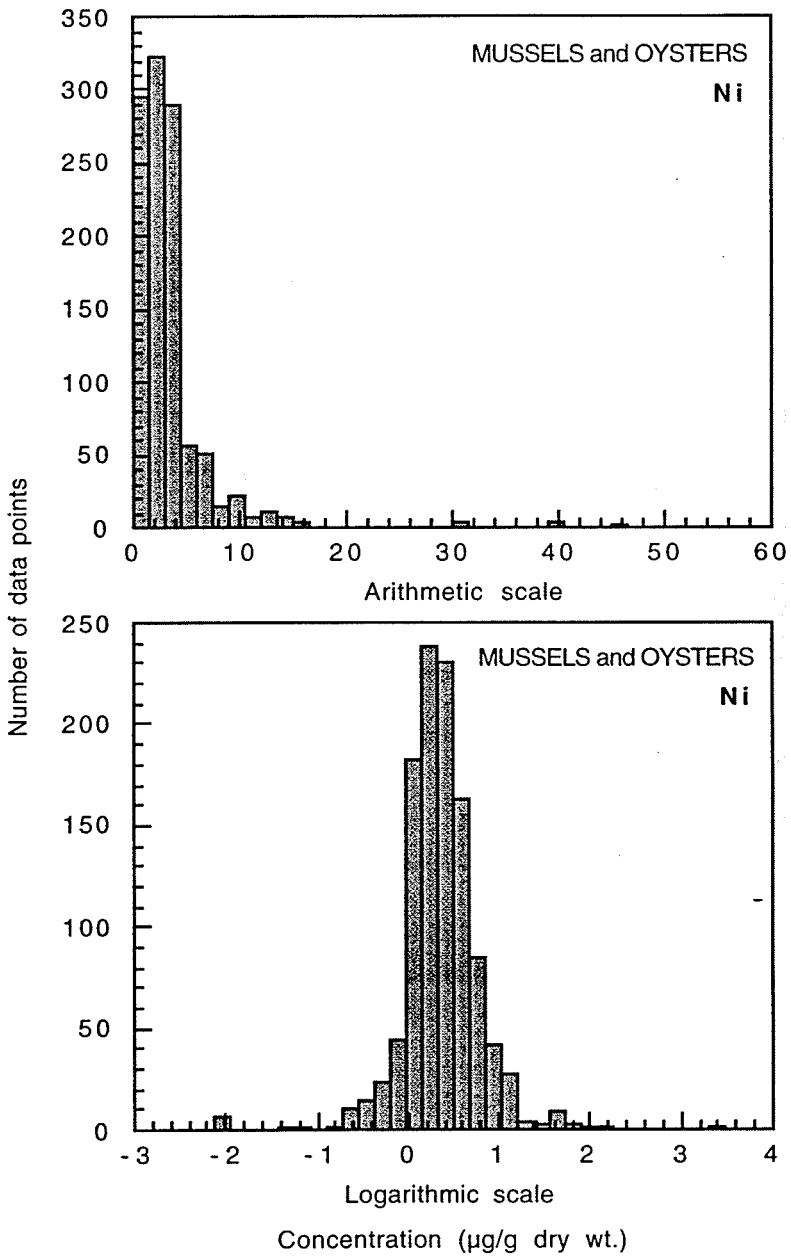

Figure IV.46. Distribution of nickel in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.2.3. Arsenic

IV.2.3.1. Basic statistics* (µg/g dry wt.)

Number of values	468
Minimum	0
Maximum	920
Mean	21
Median	6.2
Standard deviation	77

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.3.2. Graphics

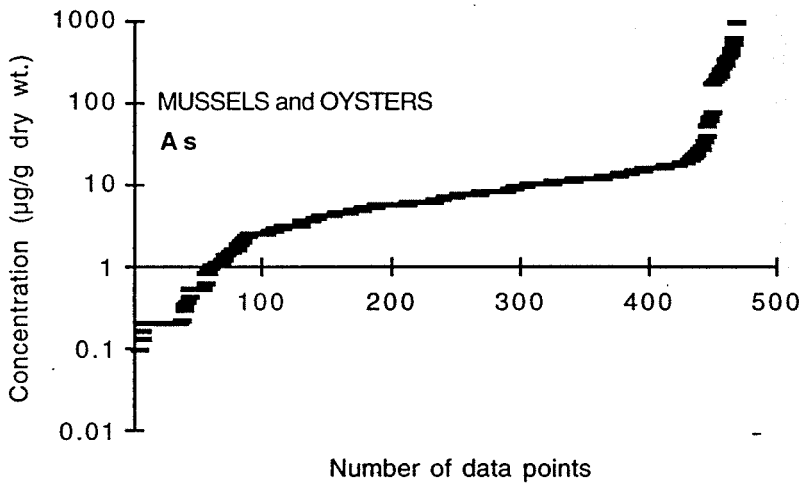

Figure IV.47. Arsenic data in WMW combined database in increasing order (µg/g dry wt.).

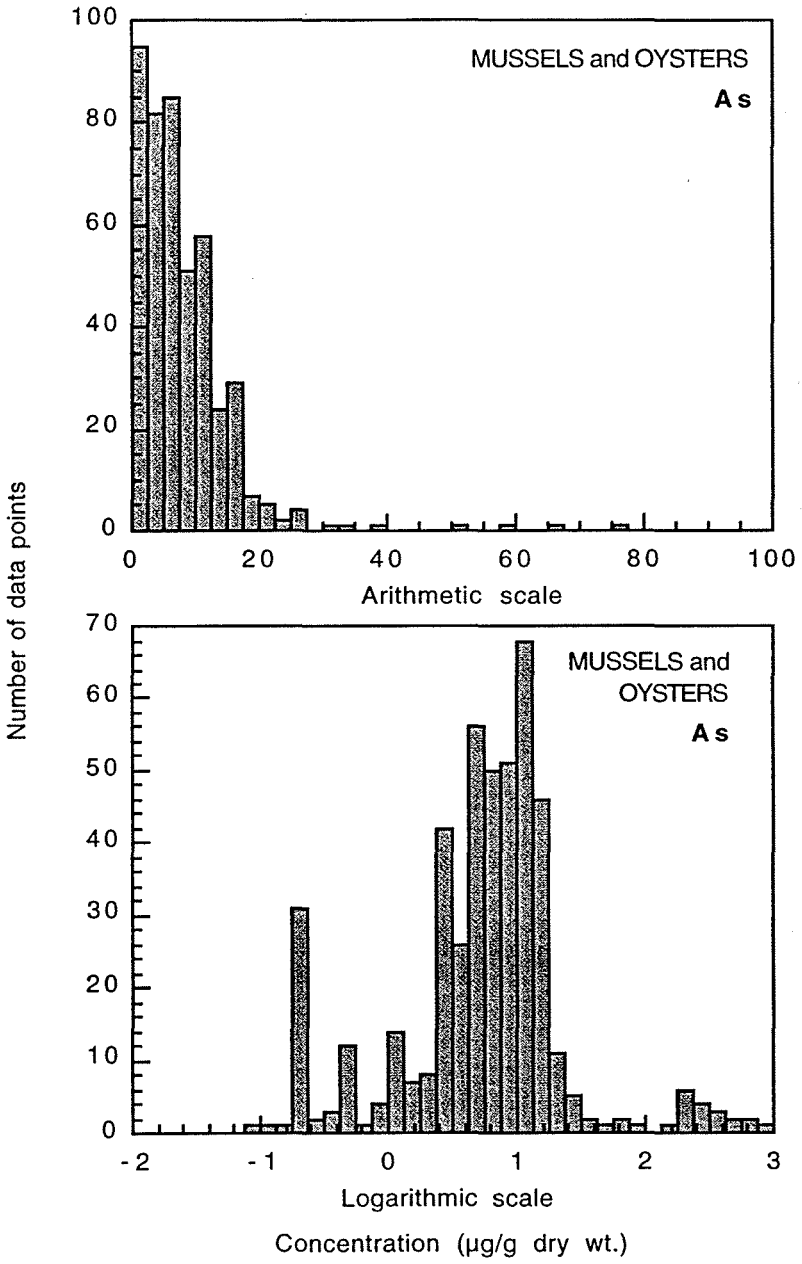

Figure IV.48. Distribution of arsenic in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.2.4. Cadmium

IV.2.4.1. Basic statistics* (µg/g dry wt.)

Number of values	3288
Minimum	0
Maximum	366
Mean	7.9
Median	2.6
Standard deviation	17

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.3.2. Graphics

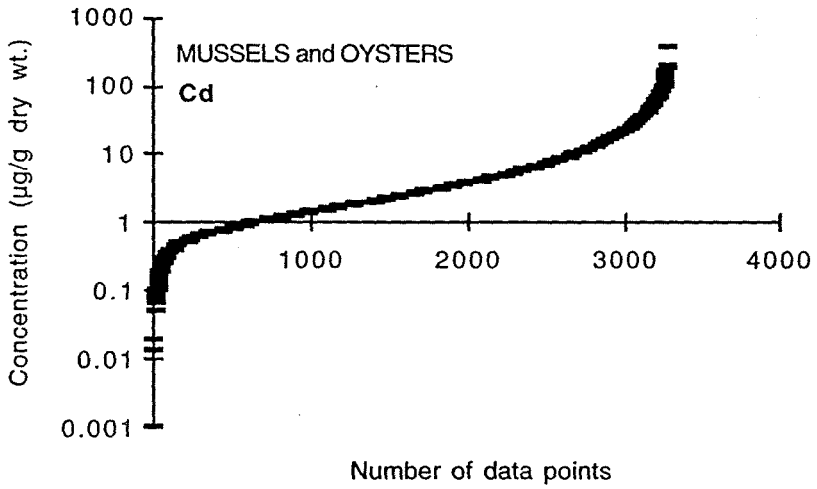

Figure IV.49. Cadmium data in WMW combined database in increasing order (µg/g dry wt.).

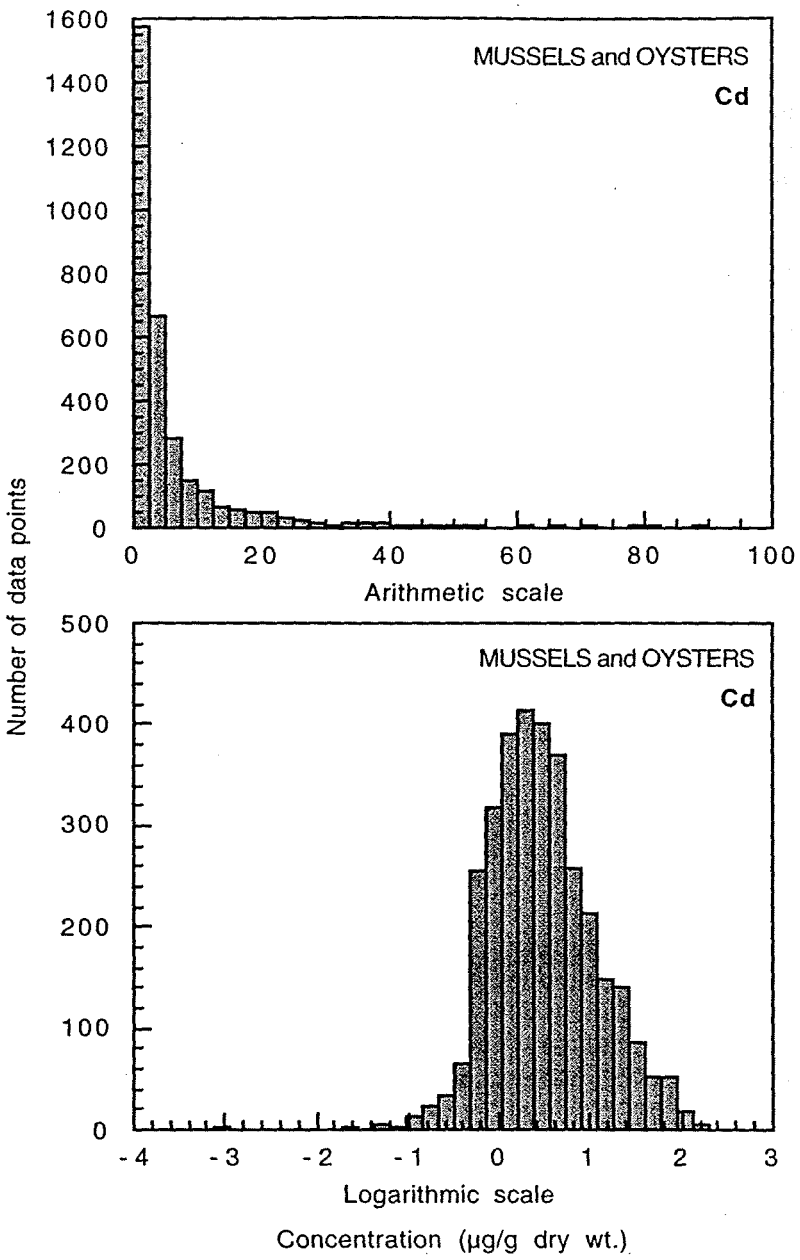

Figure IV.50. Distribution of cadmium in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.2.5. Mercury

IV.2.5.1. Basic statistics* (µg/g dry wt.)

Number of values	1488
Minimum	0
Maximum	832
Mean	3.9
Median	0.3
Standard deviation	31

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.5.2. Graphics

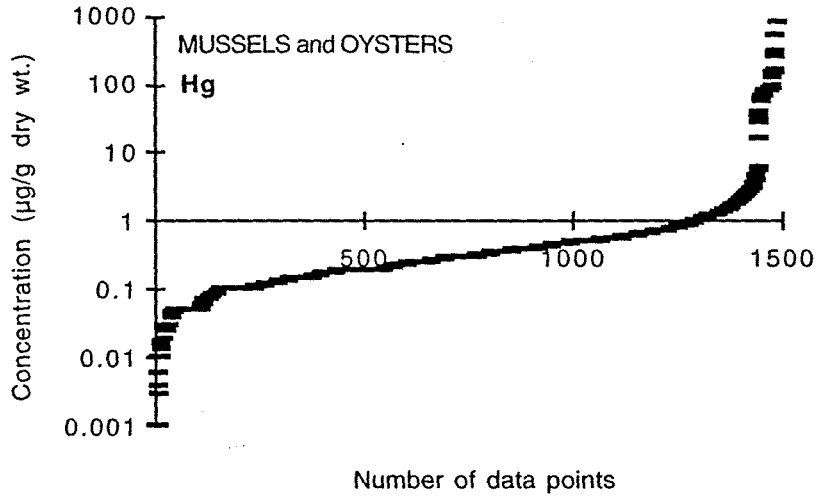

Figure IV.51. Mercury data in WMW combined database in increasing order (µg/g dry wt.).

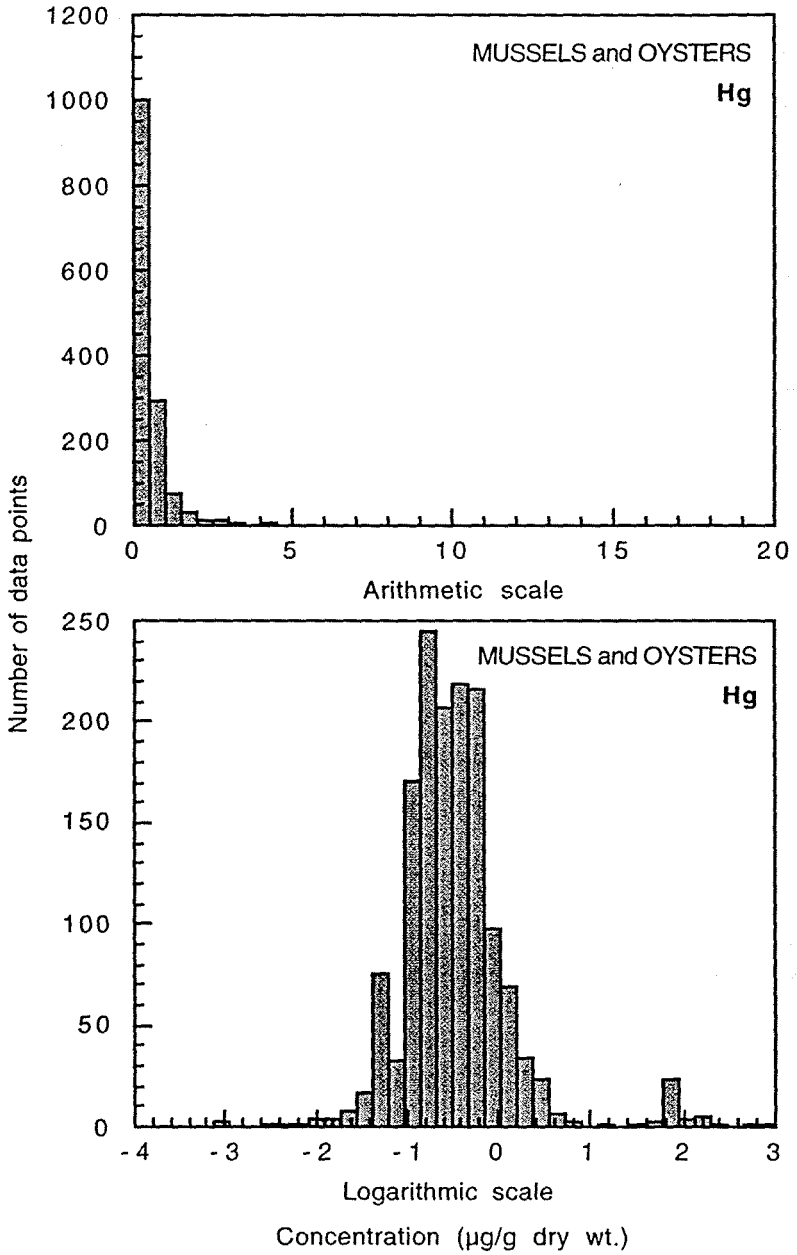

Figure IV.52. Distribution of mercury in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.2.6. Lead

IV.2.6.1. Basic statistics* (µg/g dry wt.)

Number of values	2826
Minimum	0
Maximum	6500
Mean	20
Median	3.9
Standard deviation	190

* Arithmetic values of all data used and corrected to dry weight by multiplication by 5 if necessary.

IV.2.6.2. Graphics

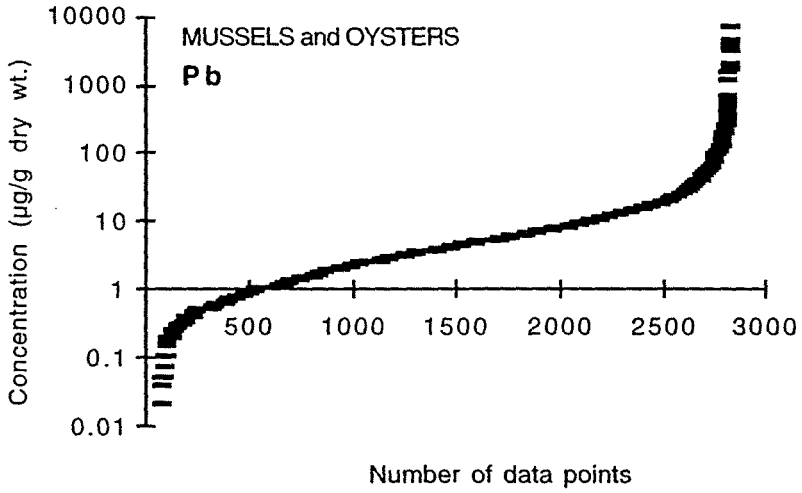

Figure IV.53. Lead data in WMW combined database in increasing order (µg/g dry wt.).

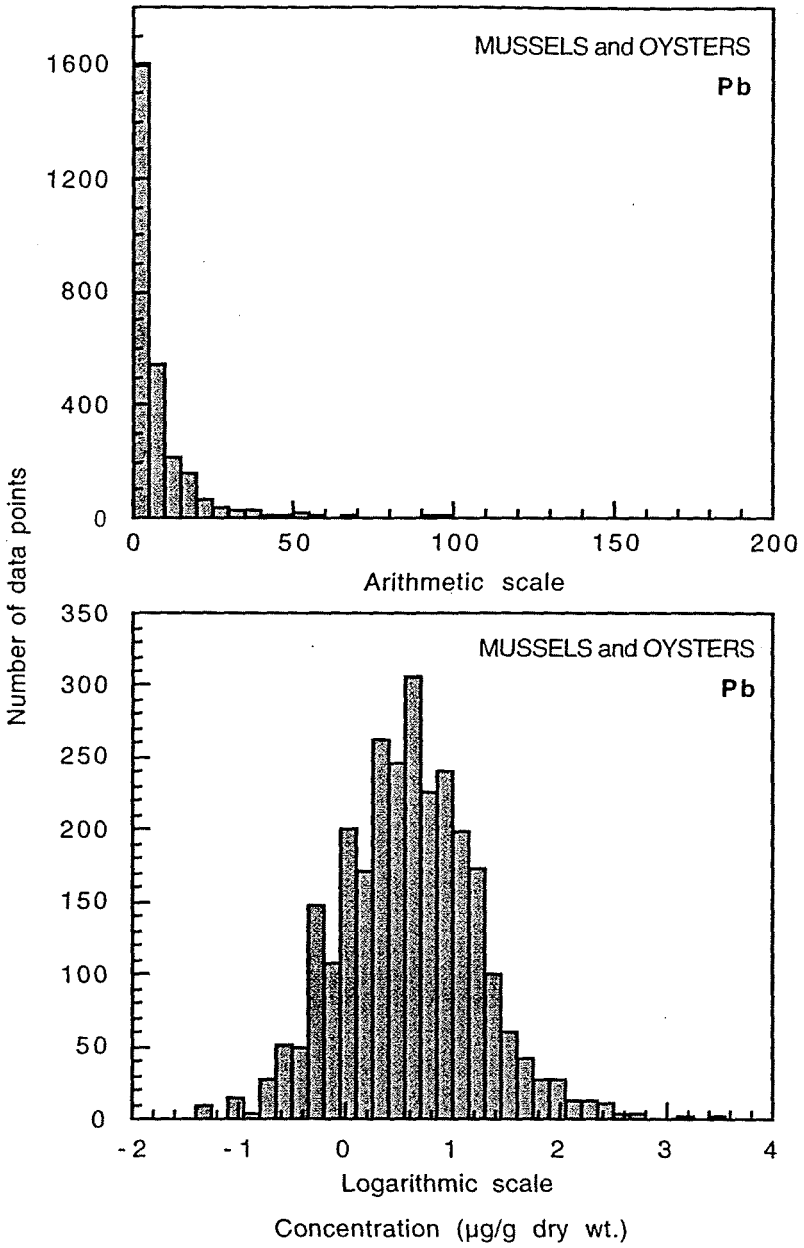

Figure IV.54. Distribution of lead in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (All data was used in calculations. Some high concentrations not shown.)

IV.3. Example of combined mussel and oyster data for elements that show species differences

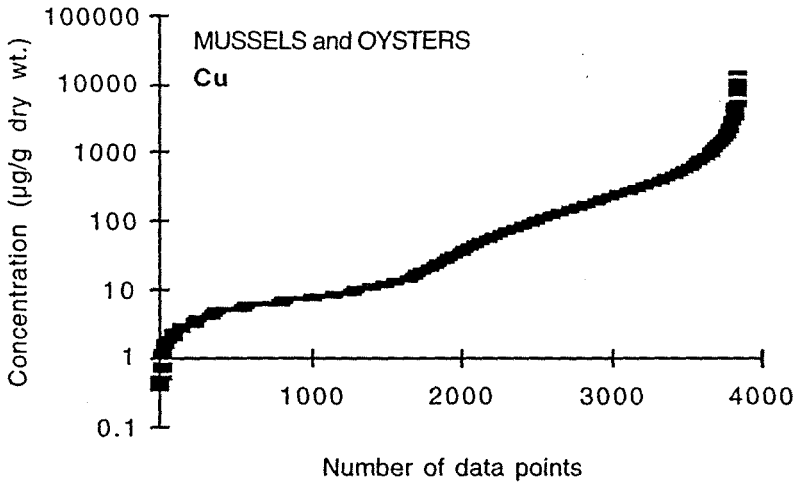

Figure IV.55. Copper data in WMW combined database in increasing order (µg/g dry wt.).

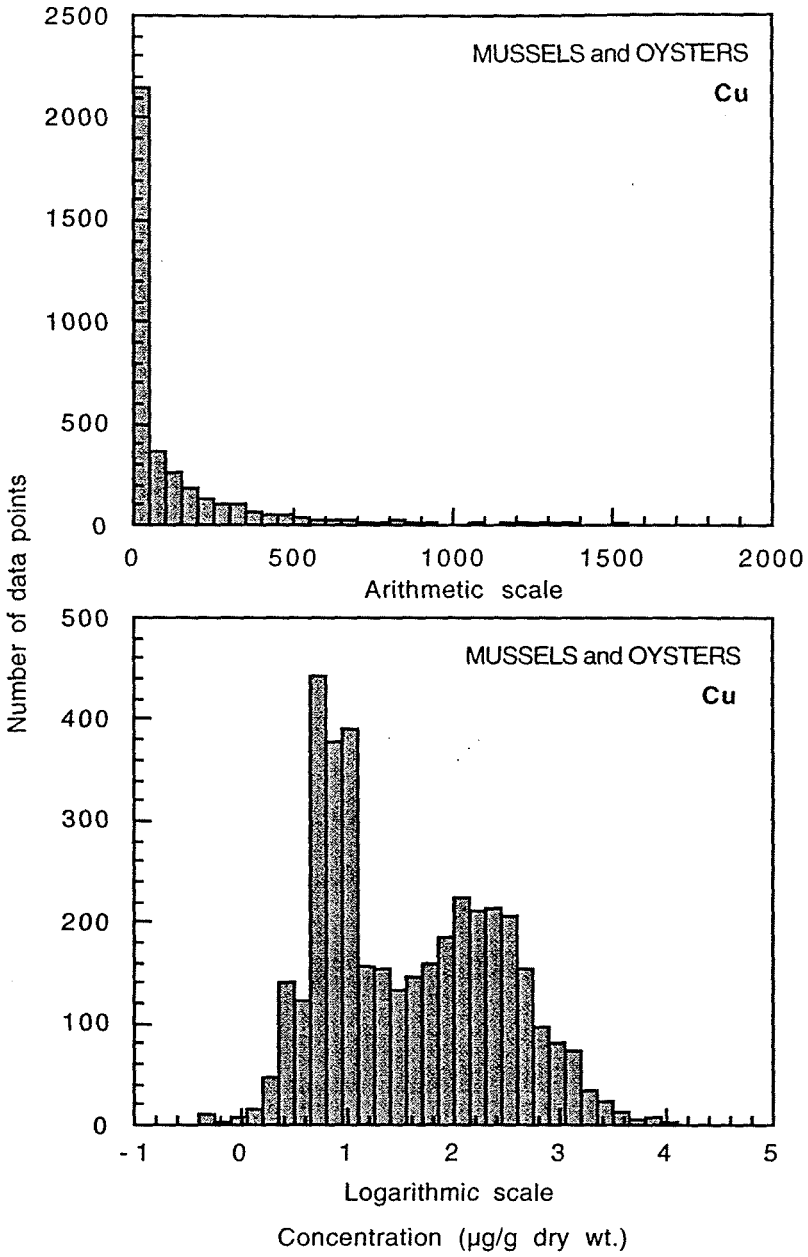

Figure IV.56. Distribution of copper in mussels and oysters on arithmetic and logarithmic scales (µg/g dry wt.). (WMW mean is the mean of the logarithmic values and the WMW high is the mean plus one standard deviation of the logarithmic values. All data was used in calculations. Some high concentrations not shown.)